

POPULAR SCIENCE

THE WORLD'S LEADING SCIENCE AND TECHNOLOGY MAGAZINE **INDIA**

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EXPERT IN ANYTHING

with guide
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TYSON**

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Patron Saint
of Experts

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START A SCIENTIFIC REVOLUTION
MAKE (ROBOT) FRIENDS
INVENT the FUTURE

AND OTHER
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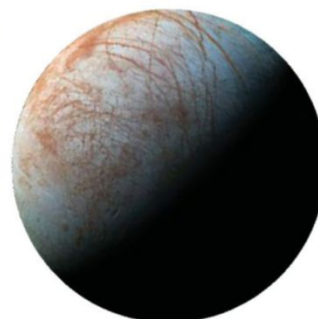
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UBER POWERFUL

The car-service company has a brazen plan to dominate robotics. Should we be excited or afraid? **ERIK SOFGE**
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THE LESS-NOBLE NOBELS

The annual tribute to science's funniest research celebrates 25 years.
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EUROPA OR BUST

Jupiter's moon might hold the life we've long searched for in space. Scientists have one shot to reach it.
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GO HACK YOURSELF

Tired of the body you have? Consider a few aftermarket options. **BOB PARKS**
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ON THE COVER

Head of the class with Neil deGrasse Tyson. Photograph by **F. Scott Schafer**

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HOW TO BE AN EXPERT IN ANYTHING

Want to start a tech empire, pioneer a new field, or revolutionize an existing one? We asked 12 geek idols—including astrophysicist and TV host Neil deGrasse Tyson—how to triumph in science and technology.



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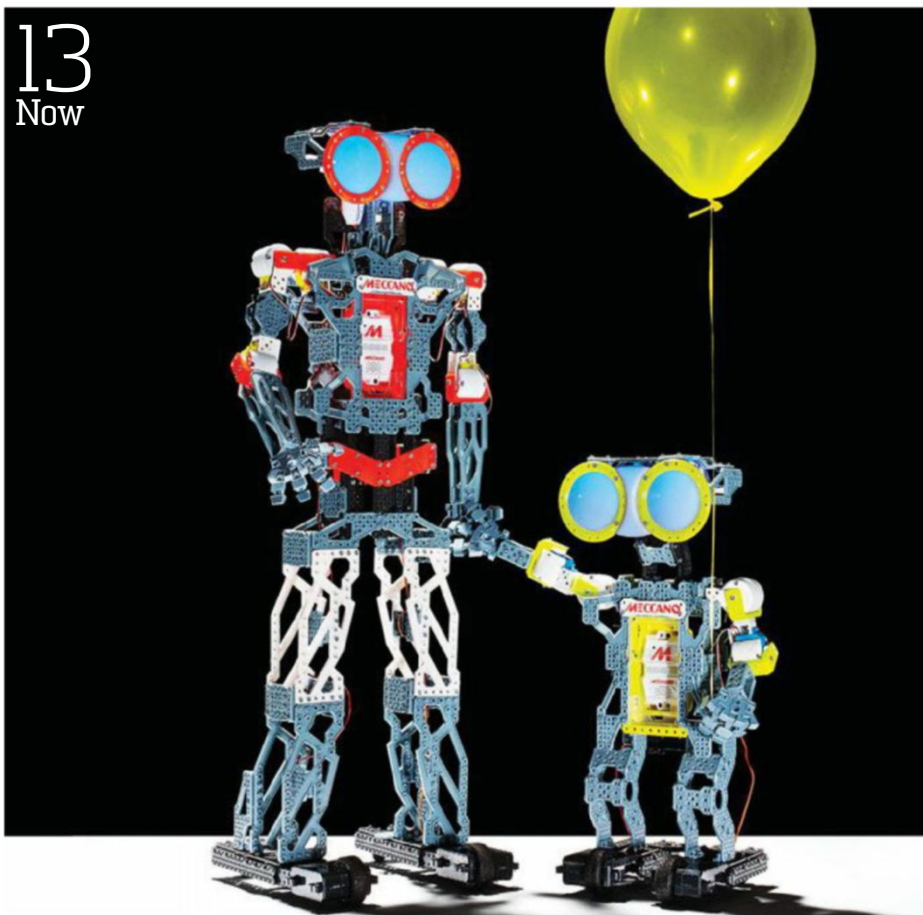
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Spotlighting Expertise

Have you ever stayed up day dreaming of the next awesome invention that would put you on the map, with the who's who of great innovators? Something that would start a science revolution. Or, how about building a tech empire, make robots, or be the next Zuckerberg? This issue, we tell you all about becoming an expert, straight from the horses mouth, as 12 professionals who have achieved idol-level status in the all-conquering world of geekdom dole out valuable wisdom.

While on the topic of experts, that Uber has been disruptive in the public transport space is undoubtedly clear. Now, the leader in transportation network has gone a step further by venturing into the world of robotics. Strap on for some more excitement (or fear?)

And here's some out-of-the-world news. While every space scientist was training all his efforts on finding water on Mars, Jupiter's moon, Europa has shown signs of more water than Earth.

This issue of PopSci also showcases the funny side of science. Find out all about the winners of the Ig Nobel awards, now in their 25th year. Here's a sample: The author of a study on side effects of sword swallowing did the thing that would prove his hypothesis: he swallowed a sword. On that note, here's hoping this issue inspires you to try your hand at something!

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Contributors



Bob Parks

For "Go Hack Yourself" (page 60), writer Bob Parks reported on people who implant devices in their flesh that allow them to do things like hear colors and see in the dark, and that led him to want a few superpowers of his own. He plans to implant a magnet in his fingertip so he can feel electric fields and dangle pins from his finger (a great party trick). Parks says, "My kids think it's a stupid idea."



Erik Sofge

Contributing editor Erik Sofge loves robots. His Twitter bio reads: "I am weak, and they are strong." So when he heard that the car-service startup Uber had hired away dozens of roboticists from Carnegie Mellon—home to one of the nation's top robotics programs—for a secret project ("Uber Powerful," page 48), he felt compelled to investigate. "This is a story I had to write," he says.



Tiffany Farrant-Gonzalez

When data designer Tiffany Farrant-Gonzalez moved from England to Vermont a few months back, she caught the worst head cold she'd had in years. After putting together the infographic for "Your History in a Drop of Blood" (page 34)—about a test that shows your lifelong record of viruses—she's determined to find the culprit's lineage. "I'm sure I have dual-virus citizenship," she says.

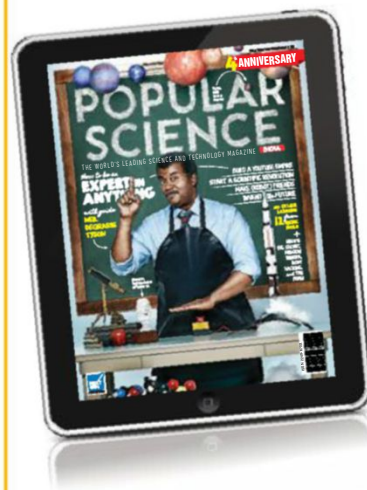


R Srinivasan

The Managing Editor of PowerWatch India magazine is also an avid petrol-head and loves classic cars. So he chose to pen down his thoughts on the cute four-wheeler Google creation ('Car with a Minion dollar smile') that believes in the safety of both passengers as well as pedestrians, and not in 'keeping pedestrians in running condition'.



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Peer Review

Loved reading the feature about the high-altitude balloons. I mean everyone loves hot-air balloons as a way of sightseeing. They've become really popular. But this really takes that idea to a new level! I wonder if it will actually work! Hope so. And the rest of the issue was fun too.

Manisha Singh, Mumbai

I thought the articles on microbes was a real eye-opener. In today's day when you have so much alarming news about the levels of pollution in the country and how unclean everything is, it's enough to make parents really paranoid. But we do tend to forget the 'good' bacteria that is important for our survival! Really enjoyed the article. It gives a whole new perspective to the idea that too much sanitization can actually be a bad thing!

Himani Modi, Delhi

I really enjoyed reading about the Tesla. That car is everywhere! And the best thing is that it's electric! Its really great to see the inroads the idea of non-fuel cars are making, and that too when it has become so essential. The car looks brilliant. Hopefully other car manufacturers will follow in Tesla's footsteps. The rest of the issue was also fun, especially the hot-air balloon ride!

Rohit Karmarkar, Pune

I love reading science fiction so I absolutely enjoyed the 'Dispatches from the Future' feature! It was a really cool idea to have well-known authors imagine what the



future would look like. I especially liked the stories by Karen Lord and Will McIntosh though all of them were really good. Hope you carry more such 'sci-fi' features in the forthcoming issues.

Vivek Shah, Kolkata

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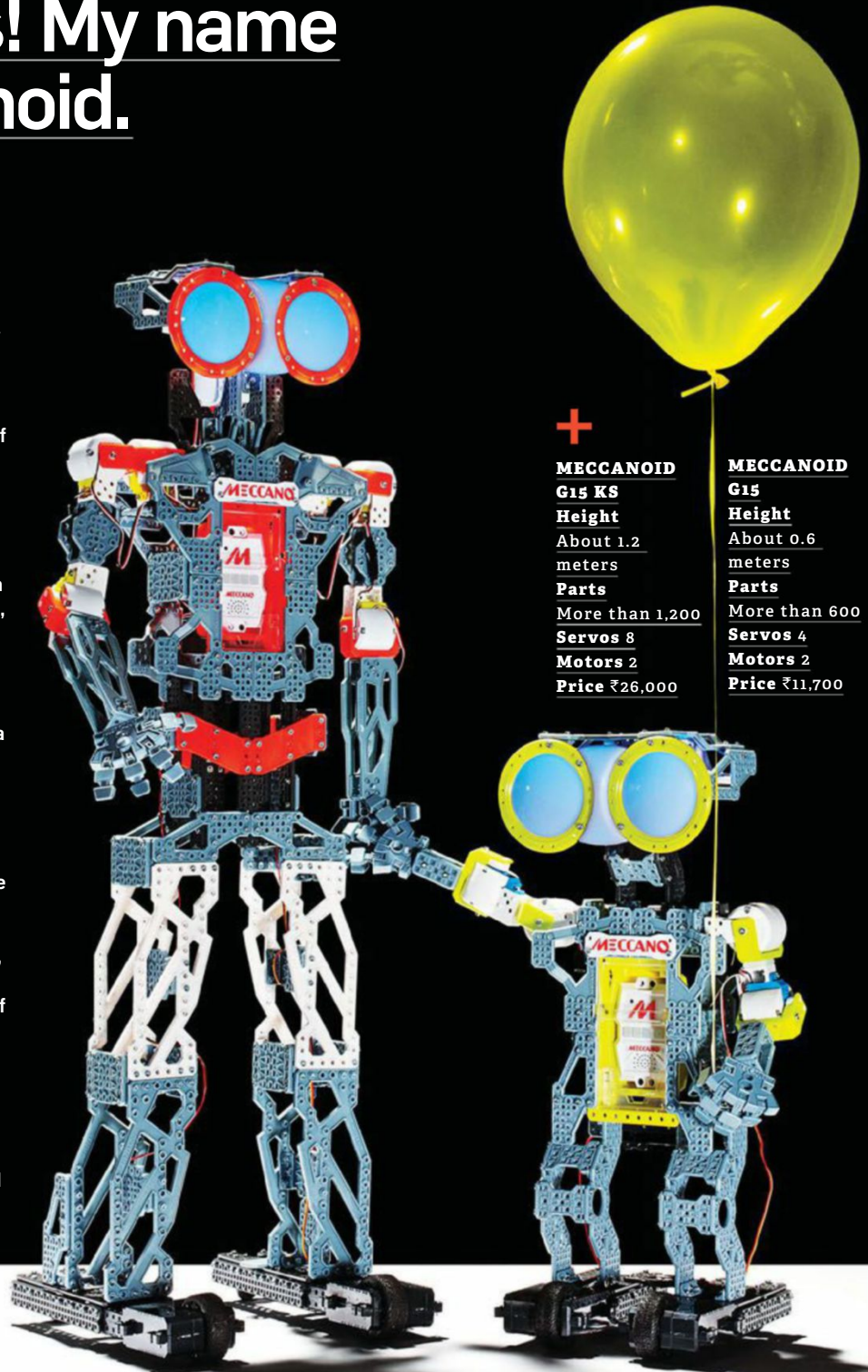
Greetings! My name is Meccanoid.



Tinker Toys. Legos. Lincoln Logs. They're all great. But none them can compare to the snap-it, screw-it, city-building brilliance of the Erector set, which has inspired tiny tinkerers for more than a century. The latest kit from parent company Meccano is the Meccanoid—the smartest DIY bot to ever spill out of a box. The kit contains hundreds of parts that you can reassemble into countless forms—from scorpions and spiders and kid-size raptors to these lovable humanoids. (Awww.)

Once assembled, Meccanoid can crack jokes, act on voice command, and be programmed with custom moves. You can do this in three ways. First, the robot can learn movements as you adjust its arms and head, just like you would with a puppet. Second, when paired with an app, you can control Meccanoid using a drag-and-drop skeletal avatar on a smartphone. Third, you can put a phone in Meccanoid's chest cradle. The robot can then use the phone's selfie cam, along with an app, to mirror your gestures.

Unlike heavy-metal Erector sets, Meccano's parts are made of plastic. The reduced weight (and lack of sharp edges) means it's not going to hurt anyone if it tips over. And although the parts might look a lot different than the metal ones that premiered in 1913, these kits are made with the same original intention: to light up the imagination and get you building. **MICHAEL NUÑEZ**



MECCANOID

G15 KS

Height

About 1.2 meters

Parts

More than 1,200

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Motors 2

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G15

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The Future Arrives by Sedan



When the BMW i8 rolled off dealer lots this past year, the few gearheads who could afford one (sticker price: \$136,500) were awed: Zero to 96.5 in 4.2 seconds, a carbon-fiber body, and a slate of futuristic features, including a no-blind-spot panoramic view of the road, made this three-cylinder hybrid a list-topper in several categories.

Now BMW is pouring the i8's feature set into its more classic and affordable models. The 2016 7-Series is the first. Its carbon-fiber body gives it similar athleticism to the i8—a huge benefit for a wide, but spacious, four-door sedan.

2016 BMW 7 SERIES

0-96.5 speed

5.6 seconds

Engine

315 horsepower

Fuel economy

9 kilometers

per liter

Price ₹48,10,000

The 7-Series also packs in a few innovations of its own. It's the first car in the world to offer gesture control, allowing drivers to direct the infotainment system like a symphony conductor. A camera in the dashboard uses 3-D sensors to watch the driver's hand movements. With various midair swipes and swoops, drivers can adjust stereo volume, answer phone calls, or activate navigation to preset destinations.

The interior is made of carbon-fiber reinforced plastic to make the car lighter and stiffer. This improves the car's handling and reduces its total weight by 86 kg, which increases fuel economy. The plug-in hybrid model goes even further with a 2-liter gasoline engine, and an electric motor in the transmission. In electric driving mode, the 7-Series has a 37-km range and a top speed of 120.7 km per hour.

To boost interior atmospherics, BMW etched hundreds of tiny dots in



DESIGN OF THE MONTH

SRT Tomahawk X

With 2,500 hp, a top speed of 643 kmph, and a partially pneumatic drivetrain, the SRT Tomahawk X could revolutionize racing. Its design, already optimized for downforce and reduced drag, employs movable aerodynamic panels to adjust its shape on the fly, improving cornering and stability for every stage of driving. The car is at least 20 years away, but you can drive it today—by downloading a virtual model with PlayStation 3's *Gran Turismo 6*.

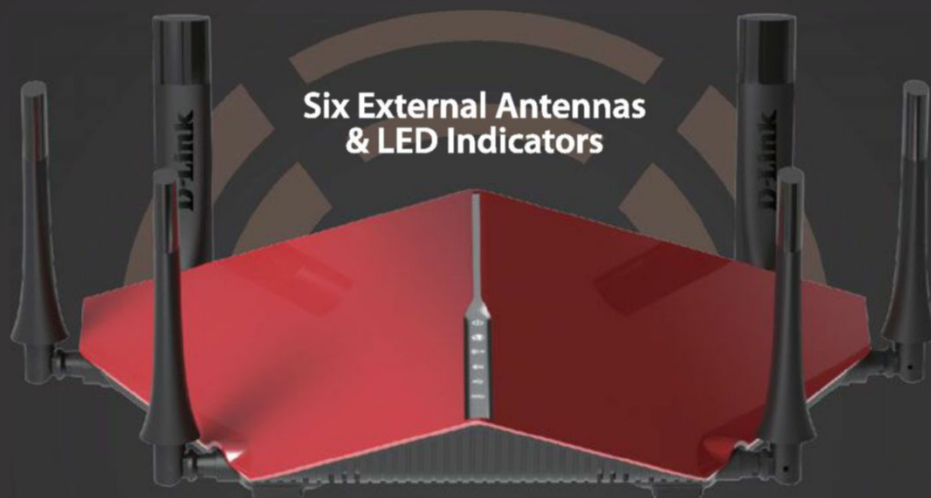
the panoramic moon roof, all lit by a perimeter of LED lights. The result: a calming field of stars floating overhead, even on the cloudiest of nights. The whole car will leave many similarly star-struck. **ERIC ADAMS**

“Gesture control allows you to direct the infotainment system like a symphony.”

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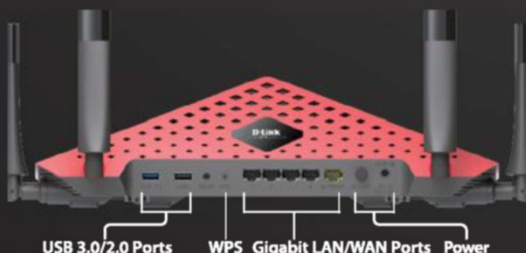
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A HEADPHONE GROWS IN BROOKLYN

Audiophiles speak in reverent tones about the Grado family and their headphones—even though Grado Labs, which makes them, hasn't spent a dime on advertising since 1964. The warm and full-bodied sound of Grado's handmade headphones have been enough to keep them consistently stocked in high-end audio boutiques. Sadly, earlier this year the company founder and family patriarch, Joseph Grado, died. The Grado kin have now decided to pay homage to him and their Brooklyn legacy with a limited-run headphone—made from a local maple tree once destined for the wood chipper.

Their new Heritage Series GH1 headphones are carved from a tree that stood near the company's original headquarters in industrial Sunset Park, Brooklyn. "These trees were about to fall down," says 24-year-old apprentice, and great-nephew, Jonathan Grado. "We bought one from the city and made a bunch headphones."

His father, John Grado (founder Joseph's nephew), has run the company since 1990. He hand-tunes every headphone the family ships.

"What people love is our mid-range sound," says John, noting that 80 percent of all music we listen to lives in that sweet spot. Up until now, the Grados have relied on mahogany, known for bringing beefy mids out of an otherwise balanced sound. The Heritage Series uses maple, which offers bright highs, punchy lows, and a more precise sound overall.

To tune his headphones, John uses an intuitive rather than a technical approach. "I never watch the frequency meter," he says. "If I look at a meter, I'll start hearing what it's displaying and not the true sound." But it was Joseph Grado who gave him that golden ear. "My uncle trained me," he says. "He taught me that listening to sound is like looking at a painting. You're not looking at the whole painting. You're looking at the brush strokes, listening to a particular part of a song. You really have to get in there and listen."

MICHAEL NUÑEZ

THREE GENERATIONS OF GRADOS



Joseph Grado
Handcrafted turntable needles.



John Grado
Made the first Grado headphones



Jonathan Grado
Heir to the Grado headphone legacy.

The Robot Whisperer Upgrades Your Hotel Stay

EDITED AND CONDENSED BY
LINDSEY KRATOCHWILL



Soon hotels will be teeming with robots. At least that's the hope at Savioke, a startup that develops robots for the service industry. The company's room-service helpers have made more than 4,000 deliveries so far. Its newest robot, Relay, has been deployed in about 10 early-adopter locations, delighting most guests but committing the occasional faux pas. To find out what it will be like when there's a robot in every hotel, we spoke with Tessa Lau, Savioke's co-founder and chief robot whisperer.



DASH

Savioke

“OUR GOAL IS TO CREATE TECHNOLOGY THAT DISAPPEARS INTO THE BACKGROUND, WHICH IS HARD BECAUSE ROBOTS ARE SO SEXY.”



Popular Science: How exactly does a robot work in a hotel?

Tessa Lau: It's a delivery robot. When the front desk needs to send an item up to a guest room—an amenity like a toothbrush or a towel, or a sandwich or a snack—they go over to the robot, put the item into its compartment, and send it off. Relay knows how to take the elevator and make its way up to the guest's room. When it gets there, it calls the room phone. So the guest comes to the door, Relay opens its compartment, and the guest retrieves the item. We got complaints when the robot just delivered its item and went home. Now it stays a little bit to interact with the guest. It gives people a chance to shoot video or take a selfie with the robot before it heads on home.

PS: Sometimes humans can be creeped out by robots. How do you overcome that?

TL: One design element is the robot's eyes. They blink. They're on its little tablet. That makes the robot look more human, a little cuter—but yet, not fully human. That's one of the balances we have to strike. If it looks too humanlike, people assume it can do

things that it can't. We already have people saying “Hi, robot, how are you?” It's hard for a robot to respond to that. So it doesn't. And in a similar vein, it makes little beeping noises rather than talking to you. That's because we don't want you to think it's smarter than it actually is.

PS: What happens when it doesn't respond like a human would?

TL: There was one incident in the Aloft Cupertino hotel where a little girl saw it and got so excited. She went up to it and hugged it, and was dancing all around it. The robot was trying to get past her into the elevator, but she was blocking its path. And at that point, an inebriated man came up and got angry, and so he kicked the robot and slammed it into the elevator. It was fine—robots don't get angry. So the robot just found itself in the elevator, turned around and faced the door, and went to the second floor. We build them to withstand enough abuse under daily use.

PS: How does it make you feel watching Relay work?

TL: I wrote a lot of the code behind it, I had my hands on so much of the technology, and I saw it being built. Even so, it's amazing just watching it do its thing. The robots start to take on personalities. You could say it's because they have slightly different motor adjustments underneath. They're each calibrated a bit differently. Therefore, they have slight variations in performance. They start to take on little quirks. Like, the one guy I was working with yesterday—Beta 6—it's really quiet. It rolls along so smoothly, you can barely hear it coming. And it just peers around the corner. It's still magical watching it go.

PS: Where else do you want to deploy Relay in the future?

TL: There are a lot of places where it could be useful. As a side project, we're looking at robots in elder care, and we've seen interest from places like sports stadiums—to do deliveries to box seats—office buildings, on cruise ships, airports, restaurants, hospitals. They are all indoor spaces where stuff has to move around—and we can help. 

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LINDSEY KRATOCHWILL

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This laptop-tablet hybrid is the first of its kind. With a 4K screen, you can edit your ultra-high-definition footage and then flip the screen to show off your dazzling creation. **₹78,000**

2 HYDROFOIL DRONE

Parrot's Rolling Spider drone is pretty fantastic, but it's not made for water. The company has fixed that shortfall with the Hydrofoil. The flying drone can now attach to a pair of skids that can glide across water at speeds of about 6 mph. **₹11,635**

3 TORQUE T402V

Can't decide what kind of headphones to buy? Torque makes it easy. With a quick adjustment, users can pop off the ear pad and turn it to change the amount of bass to their liking. **₹26,000**

4 VARIA SMART BIKE LIGHTS

Thanks to GPS data, Garmin's new lights know when you're blowing ahead at high speeds or inching along in traffic. The beam automatically projects farther at faster speeds so you can see obstacles ahead. **₹19,500**

5 SUPER MARIO MAKER

It's been 30 years since the mustachioed plumber started hopping around screens. To celebrate, Nintendo's new Wii U game lets you design your own levels. And if that's too much

work, you can try ones designed by other players too. **₹3,900**

6 WORX AIR WITH TURBINE

Blowing damp leaves off the lawn requires big blasts of air. Worx redesigned its cordless blower so the airflow intake moves air straight through the nozzle without the usual baffling. If you don't need all that power, witch outputs to handle lighter jobs. **From ₹6435**

7 PIXIE TRACKER

Don't know where the keys ran off to? GPS trackers don't work well indoors, and Bluetooth signals offer only proximities. So the Pixie trackers use mesh networks to connect to each other to give more-accurate locations. **₹4,550 for four**

8 IBM CHEF WATSON

The brain that beat Ken Jennings in *Jeopardy* can now help you make dinner. The Watson Web app, formerly in beta, is now available to anyone. Type in a few ingredients to see what quirky recipe combinations Watson cooks up. **Free**

9 CHILLED

The hulking fridge might not seem like cutting-edge tech. But in his new book, Tom Jackson describes how the ability to cool things down has changed history. And since refrigeration has helped discover superconductors and enable in vitro fertilization, it's likely to change the future. **₹1,755**

10 ANKI OVERDRIVE

Robotic toy cars are already cool; Anki has made them cooler. Players can now pit toy supercars against friends (or nemeses) and against the AI commander on their own customizable racetracks, thanks to modular, magnetic pieces. **₹9,750**





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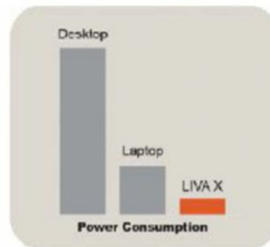
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A LEAN, MEAN STREAMING MACHINE



There's a universal truth about home entertainment: Slow speeds kill your buzz. Everyone hates buffering (when streaming movies) and image stuttering (when playing video games). Nvidia has solved both problems in one device. It's a 4K video-streaming set-top box that doubles as a gaming console.

The Nvidia Shield uses a mighty Tegra X1 processor, the fastest mobile chip on the planet; it has 256 CPU cores that can run at 1 teraflop. What does that mean? For gamers, it's no more lag when questing for dragons in *The Witcher 3*. For movie buffs, it's seamless video playback.

The Shield runs on Android TV, an operating system that syncs to the Google Play store, which offers downloads for movies, music, games, and more. The Shield also has a handy Google Voice search built into the console, so it can answer questions like, "Do I need my umbrella today?" Sports scores, stock reports, and breaking news are also available via voice command. You can get all the information you need for the day just by asking for it. And because the streamer can act as a Chromecast, it's easy to mirror anything from your Android phone or tablet.

A pencil-thin remote and gaming controller ship with the device, and provide wireless access to all its functions. The Shield comes with a gigabit Ethernet port—which is more than 40 times faster than the average American home's Internet speed—meaning you'll probably never touch the limit of this machine. That kind of Internet throughput, combined with the blazing-fast Tegra X1, ensures the Shield will never hit a speed bump.

DAVE GERSHORN



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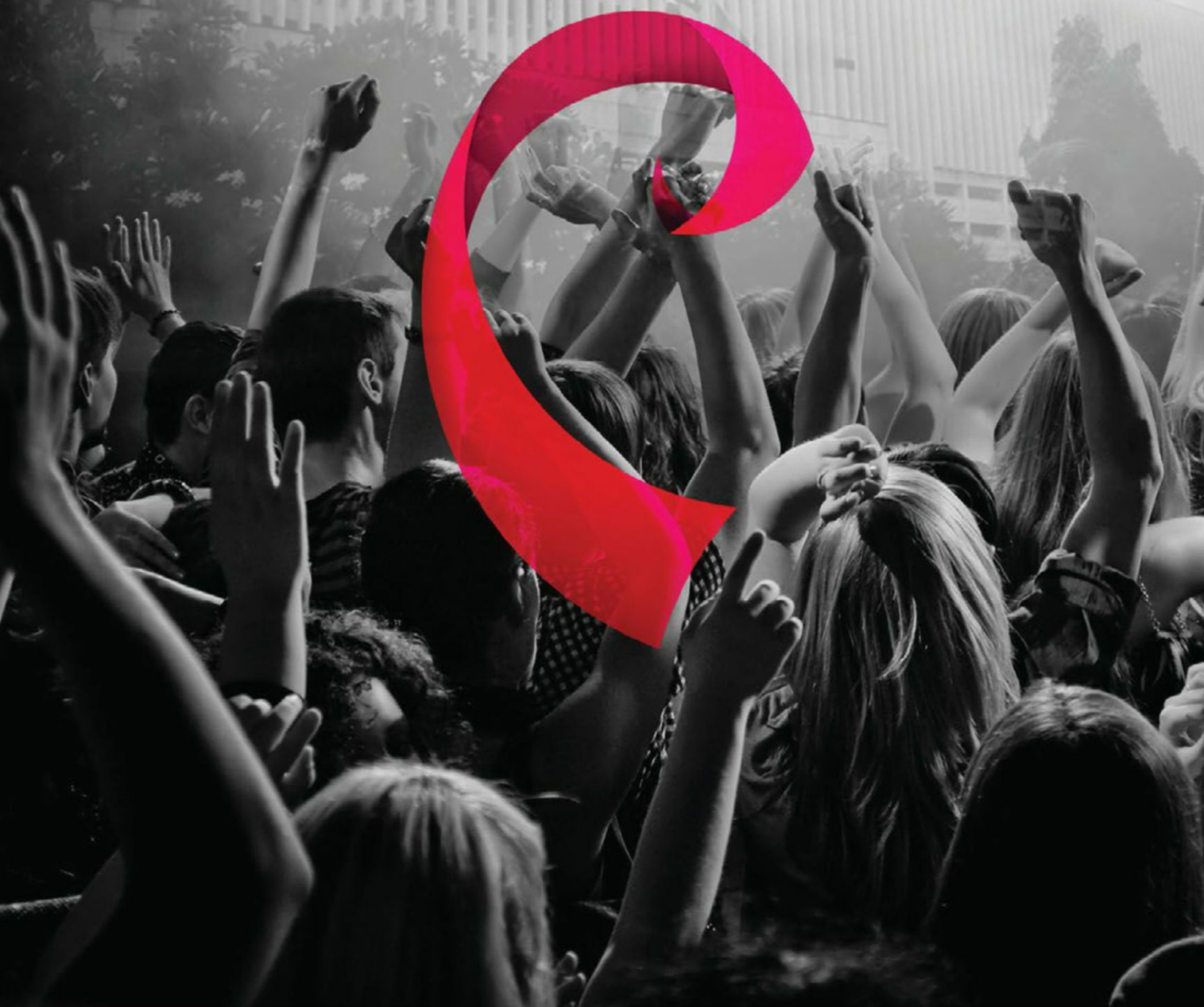


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PROBLEM

Waterproof jackets aren't good multitaskers. Sure, vinyl or PVC slickers are impenetrable, but while they keep rain out, they lock sweat in—making you feel clammy. One fix is the waterproof breathable jacket. The key to its success is a delicate membrane sandwiched between two layers of fabric. Unfortunately, during downpours, the outer layer soaks through, making you feel damp. And adding to the discomfort, the glue that holds the fabric layers together ends up trapping perspiration inside.

SOLUTION

The Columbia OutDry EX Diamond Shell (₹26,000) puts its waterproof breathable membrane on the outside. A grid pattern of abrasion-resistant polymer protects it from the elements. Because the membrane is heat-fused with the polymer and the inner fabric layer, it does away with sweat-trapping glue. If you do work up a sweat, the inner layer wicks it away through the outer membrane. It works so well that Columbia plans to use this same construction on its down jackets, which were previously hard to protect. **BERNE BROUDY**



The Little Fix TINY-TOOL TAKEOVER



Emergencies rarely announce themselves, so carry all you'll ever need in your pocket.
LINDSEY KRATOCHWILL



1 MACHINE ERA TITANIUM MULTITOOL

Machined, as its name implies, from a block of titanium, this multitool has a Phillips-head and flat-head driver, a pry wedge and both a 1-inch and a 2.5-centimeter rule. A hand-blasted matte finish defies scratching. ₹2,080

2 METAL DREAMER PINCH

It's hard to imagine this titanium chunk encompasses 11 tools—including a wire stripper, nail puller, hex-bit holder, and bottle opener. Despite the sparse look, the company designed it with function in mind—there's plenty of space to hold it. ₹1,430

3 PANGEA DESIGNS PICO

This extremely minimalist item by Pangea is crafted to be a bottle opener. You'll hardly notice PiCO in your pocket—it weighs about as much as two paperclips, and keeps a low profile because the key ring it dangles from doubles as leverage. ₹715

4 REDUCTIVIST RINGTOOL

Always be prepared for emergency bike adjustments. Each of the eight hex-head and driver pieces is long enough to reach screws, and won't be uncomfortable in your pocket. Plus, you can use it as a bottle opener. ₹1,820

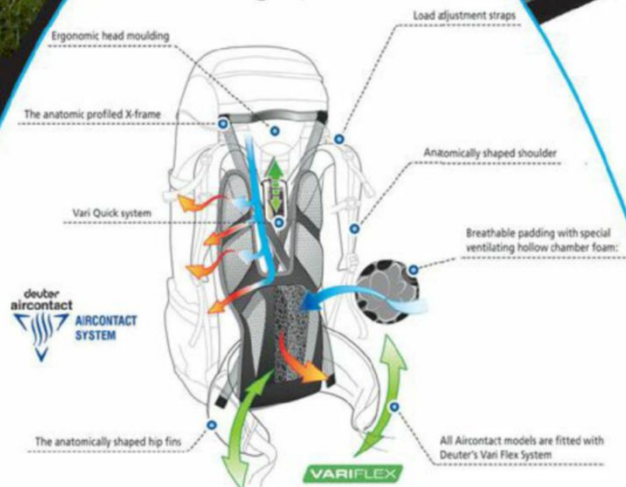


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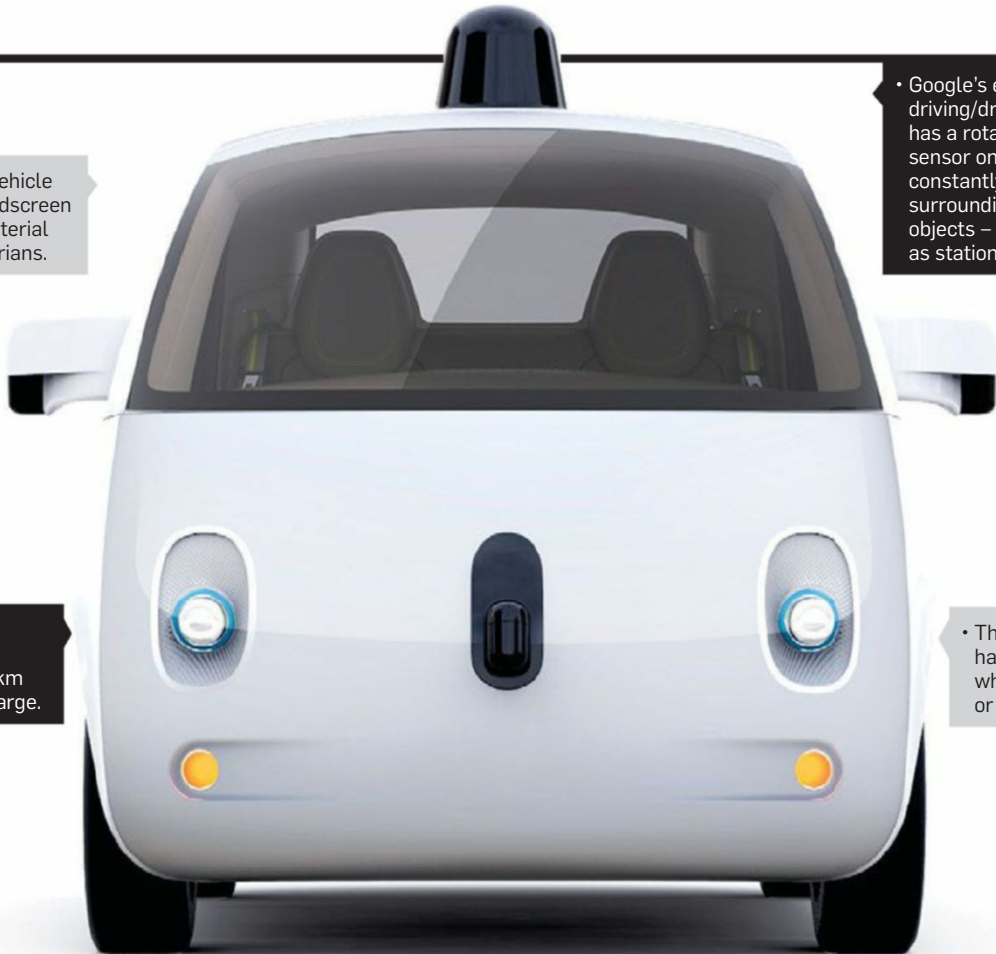
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Car with a Minion dollar smile

Story by **R Srinivasan**

Google's electric self-driving prototype employs sensors to detect objects up to 182.8 meters in all directions to tackle busy city streets.





• The front of the vehicle has a flexible windscreen and foam-like material to protect pedestrians.

• Google's electric self-driving/driverless car has a rotating laser sensor on the roof that constantly scans the surrounding area for objects – moving as well as stationary.

• Max speed is 40 kmph and it can travel up to 160 km on an electric charge.

• The two seater has no steering wheel, accelerator or brake pedal.

In keeping with its ultimate purpose to prepare for the next stage of its five-year-old self-driving car project, Google's electric prototype has two seats, standard seat belts, space for some luggage, sensors, cameras, digital maps, and a laser scanner. It has a start button and a big red emergency stop button but no steering wheel, accelerator, or brake pedal. A screen shows the route, weather and current speed. After the journey is over, the screen displays a message reminding passengers to take their personal belongings. Google has designed the entire car, right from sensors to a cabin (that does not create blind spots) and the body shell. According to its designers, the car's cartoonish looks were intended to put road users and passengers at ease with the new technology.

Software, sensors and safety -The vehicle's software is designed to tackle busy city streets, to improve road safety and to transport a person from point A to point B without

human intervention. Sensors can detect objects up to 182.8 meters in all directions and eliminate blind spots, which is helpful on busy streets with lots of intersections. It can detect objects, buses, cyclists, pedestrians, cars, lane markers, traffic signs, and traffic lights. The vehicle stays out of other drivers' blind spots, moves away from other vehicles, and can also detect ongoing road work.

Also till the traffic light turns green, it will wait for a second before moving off. But this feature, in cities like Mumbai where some drivers are usually seething with road rage, would need a rethink. The advantage of these cars is that they never get tired, sleepy, or distracted like humans, can see 360 degrees and simultaneously track hundreds of moving objects, meaning they can respond quicker than humans in many scenarios, helping them avoid



accidents more efficiently.

The speed of these prototype vehicles has been capped at 40 kmph. The car extends safety to road users and pedestrians as well—its front end has a soft foam-like material and flexible windscreen to absorb energy from an impact to reduce injuries.

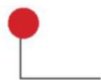
Google expects the cars to be road-ready by next year, but testing may take a few more years as they continue to refine the technology so that they can introduce self-driving cars by 2020.



If looks and affordability are the two major factors you're looking for in a phone, Zenfone 2 Deluxe fits the bill perfectly. The phone features a new multifaceted polygonal finish that accentuates the phone's design and is complemented with Zenfone 2's ergonomic arc design. Apart from looks, the Zenfone 2 Deluxe has a potent hardware like a 5.5-inch Full HD display, 13MP and 5MP PixelMaster cameras, 2.3GHz 64-bit Atom processor with 4GB RAM and LTE support.

Asus Zenfone 2 Deluxe: from ₹22,999

Availability: Out now from select online stores



Samsung's Galaxy S6 edge has gotten better and bigger. Behold the Galaxy S6 edge+ that comes with an amazing 5.7-inch Quad HD Super AMOLED Display, state-of-the-art Exynos octa-core processor, 4GB RAM, 16MP camera with optical image stabilisation, a larger capacity 3000mAh battery that also supports fast charging and most importantly a dual edge display that is enhanced by two new features – People edge and Apps edge to access contacts and apps faster.

Samsung Galaxy S6 edge+: ₹57,900

Availability: Out now

The other Samsung flagship to surface is the upgrade to its successful Galaxy Note series. The Galaxy Note 5 brings in improved Galaxy S6-like design with a curve at the back for a comfortable one-hand use. The hardware is very much similar to its other device – Galaxy S6 edge+ but comes with an intelligent S Pen that allows users to take notes on the phone even when the display is off or use it for more purposes with the Air Command feature.

Samsung Galaxy Note 5: TBA

Availability: TBA for India



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Utilities Available Now!

LG's eye-popping 4K OLED TV is now available in India. The TV offers lifelike picture quality, thanks to the WRGB panel technology and 4K resolution that makes it a cinema-like experience. The svelte 5.9mm slim curved TV also comes with all the smart TV features with Web OS onboard and a Magic Remote that comes with a point and click feature.

LG 4K OLED TV: from ₹3,84,900

Availability: Out now



Acer has brought its topmost Nitro series notebook to India. The 15-inch stylish gaming notebook boasts patterned covers made with soft touch NIL (Nano Imprint Lithography) technology and is equipped with a 4th-gen Intel Core i7 processor, Nvidia GeForce GTX 960M graphics card, Dolby Digital Plus support and a 4K UHD display.

Acer V Nitro Black Edition: ₹1,10,000

Availability: Out now



If you're looking to get the best of both worlds, Dell's Inspiron 13 7000 series works as a full-fledged notebook and a tablet. The device packs in the latest Intel Core processor, a full HD display, integrated Intel graphics, 8GB RAM, option of an HDD or an SSD and up to 6 hours of battery life. It also comes with a built-in stylus that allows you to sketch and take notes.

Dell Inspiron 13 7000 Series: ₹65,390

Availability: Out now





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First Drive / Maserati Ghibli S Q4

Fire. Power.

Six cylinders, two turbochargers, four-wheel drive and 410 PS—the Maserati Ghibli S Q4 is a completely different animal compared to its diesel counterpart. Here's what it's like





The Ghibli name has been resurrected to take Maserati to a new high in sales figures. Yes, the Italian marque always guns for exclusivity, but in today's day and age, even an icon that has completed a century needs numbers to survive. Maserati have been growing steadily with the name gaining greater prominence worldwide now than ever before. Their latest sports sedan was created to enter a segment dominated by the Germans and make its mark. Resurrecting the name of a sports coupé from almost 50 years ago seemed like a good idea, although this Ghibli has two more doors and normal—for Maserati—headlamps.

While the Ghibli S Q4 has some stunning lines, what lies underneath is what makes it more of a stunner. The V6 is a twin-turbo unit designed by Maserati and developed by Ferrari. The 3.0-liter motor makes 410 PS and 550 Nm in S guise, enough to turn the thrills up a few notches. The Q4 refers to the intelligent all-wheel-drive system, which is driven by the ZF 8HP rear-biased automatic transmission. That, to say the least, is a fine combination.

Starting up, the V6 barks and settles into a delicious idle; 'delicious' because the mix of air and fuel seems almost palpable to any petrolhead. Slot the lever into 'D', then 'S' and off we go, paddles primed. The S Q4 rockets off the line with the acoustics and ferocity of a proper Italian sports car. Turn into the right-hander leading on the straight and its foot hard down. Two blinks later I'm

up to fourth, doing 140 kmph and heading into the chicane—hard on the brakes, two clicks of the left paddle, turn the wheel right, then left, and the Ghibli is composed as ever, letting the G-forces be my mental undoing before I collect myself and throw it into another long right-hander then left, heading up the hill. At this point, gravity seems like a mere concept, and the Ghibli powers up the slope, right paddle flicked midway, and the left one again, into the almost blind right-hander. More S-bends ahead and we head downhill in anger, the Ghibli handling the speed well, the S keeping it up and the Q4 ensuring everything is in check; quite a package!

The sharpness and agility of this nearly two-tonne car is commendable and there aren't too many things wrong at all.

What is wrong, however, is something apart from the driving aspect altogether. The S Q4 is not going to set any fuel-efficiency records even with the smooth eight-speed box. Second, the price. With the diesel model available at Rs 1.1 crore, this will be in the Rs 1.4-crore range and that puts it among a crop of rather proven speed machines. Nevertheless, it's a credible car which can take to the highway and the track like a four-legged duck to freshwater and a bathtub. What it does have going for it, though, is the absence of the BMW 550i xDrive and Mercedes E500 4MATIC, but on the other hand, its price does make their even more potent versions seem like direct threats.

Track Missile

Riding Ducati's homologated world superbike, the Panigale R was certainly one helluva experience to write home about. Here it is

The superbikes have never been as close to racing motorcycles as they are today. This is thanks to the new FIM rules which insist that they use the same pistons, con-rods, crankshaft and cylinder-heads with limited modifications. This has one upshot: while trying to keep the cost of racing motorcycles down what the FIM has done is pushed the cost of superbikes higher!

Since the 1199R is primarily meant for track use, Ducati have made a lot of changes in the engine internals as compared to the 1299S.

When you have 205 PS of power on tap and only 162 kg of weight to haul, you need to have the best possible suspension, brakes and tyres to put that power down on the black top and stop the missile at the same time.

The 1199 is loaded with electronics to the gills and sets a new benchmark for electronics in motorcycles. The highly advanced electronic kit is supported by the Inertial Measurement Unit (IMU) which measures acceleration in relation to three axes and calculates the bike's angle of roll and pitch. The IMU has made it possible to increase the performance of the electronic kit, introducing Cornering ABS, Ducati Wheelie Control (DWC) and, on the S version, Öhlins Smart EC, an event-based control system of the suspension. For the first time, the Ducati Quick Shift (DQS) function is also for down-shifts. Furthermore, the 1199 is equipped with ride-by-wire (RBW) system, the Ducati DATA Analyser (DDA+) and Ducati Riding Modes, which interact with Ducati Traction Control (DTC), Ducati Wheelie Control (DWC), Ducati Quick Shift (DQS), Cornering ABS, and Engine Brake Control (EBC).

The auxiliary buttons on the handlebars, as on the race bikes, allow you to regulate DTC and DWC, and EBC also allows you to select from among three riding modes: Rain, Sport and Race.

Now it was time to see what the R was capable of and so I started using the 205 PS on tap. Once you get going from standstill, the clutch becomes redundant as it is not required for up or down shifts. The RPM shift lights kept coming on constantly as the bike's rev-happy motor kept gaining revs in a hurry. The R inspires a lot of confidence and makes you push it harder and brake deeper into the corners and makes it possible to get back on the gas simultaneously while the front brake is being released. The monocoque chassis with Öhlins suspension, Brembo brakes and the Pirelli Diablo Supercorsa tyres make the Panigale R a great package for the racetrack.



EDITED BY **Breanna Draxler**

08

Percentage of men of Northern European descent who can't tell red from green, according to the National Eye Institute



Jeans fade. The sun breaks down the dye's chemical bonds, or the Laundromat washes it away. The same cannot be said for a parrot's feathers. Those striking blues and greens come from "structural color". Nanoscopic balls of pigment reflect certain wavelengths of light but not others, creating colors purer than any dye. And since there are no chemical bonds to break, the colors can't fade. For the first time, in May, researchers created structural color in the lab. They say it could lead to longer-lasting paints or even color-changing camouflage. **LEVI SHARPE**

A Hub Away from Home



The Ecocapsule can be shipped, airlifted, or trailer-towed into place.



An Airstream offers retro appeal, but it can't compare to the sustainable, high-tech glamping you could do in an Ecocapsule. Developed by Slovakian firm Nice Architects, the portable living space runs on sun, wind, and rain alone. Throw in a cache of canned food, and you'll be set to hunker down indefinitely. The 4.5-meter, 771-kg pod can serve as a research station, disaster-relief shelter, or remote Airbnb almost anywhere. The second-generation version—which is expected to debut this fall and go on sale in 2016—includes sleeping quarters for two, a kitchenette, a shower, climate control, and even electrical outlets. Plus, it comes equipped with a custom-designed H₂O-free toilet that incinerates your waste out of existence. **CORINNE IOZZIO**

CONTOURED SHELL

The Ecocapsule's egg shape reduces surface area (and therefore heat loss) without sacrificing living space. You can stay in the pod year-round. Thin aerogel insulation—already used in buildings, water bottles, and spacecraft—is sandwiched between two aluminum-reinforced polycarbonate walls.

POWER SUPPLY

A 750-watt wind turbine and 600-watt solar array collect energy. Assuming outside temperatures stay between -25°C and 40°C, the capsule can consistently produce all its own power. A super-efficient climate-control system helps: On its way to the exhaust fan, heated air passes through channels alongside fresh air, warming it up.

ENERGY STORAGE

Should energy production dip, a 9,744-watt-hour battery holds five days of power. When the battery is charged, the system uses excess energy from the solar cells to heat up water stores, relieving strain on the water heater come shower time.

RAIN COLLECTION

Rainwater runs down the capsule and through a ceramic filter into a 549-liters reservoir beneath the floorboards. When full, it can supply two people for three weeks. Electric pumps circulate water through a membrane filter to trap dirt and bacteria en route to the sink and shower; manual foot pumps stand in when energy is low.

SMART INTERFACE

A central computer, controlled with a smartphone or tablet, monitors energy and water levels to project how long they'll last. It's also hooked up to sensors that record rainfall, humidity, and temperature outside the capsule. In periods with little sun or wind, the computer might suggest adjusting the internal temp or taking shorter showers to stretch the supply.



Dava Newman

On Getting People to Mars in One Piece



Aerospace engineer Dava Newman has devoted her career to figuring out how we might live in space—suspending subjects from the rafters of her MIT lab to study reduced gravity and designing a flexible, self-mending space suit.

As NASA's new deputy director, she is now tasked with the planning and policy that will make greater human space exploration possible. That means leading the agency's 18,000 employees and 40,000 contractors toward a successful crewed mission to Mars by the 2030s.

"If everyone isn't talking about our journey to Mars at the dinner table, I want to change that."



21

Number of Mars missions NASA has launched since 1960—of which 15 were successful

“

Right now, we have five rovers and orbiters exploring Mars. A human mission is a different ballgame. You have to think about stuff like access to water, psychological impact, radiation, and what happens to your muscles and bones in three-eighths of Earth's gravity. Those are the kinds of things we're trying to figure out on the International Space Station. The twins experiment, for example, will compare the vital signs of the Kelly brothers—one in space and one on Earth—to see physiological and genetic differences.

After the ISS, the next phase will be to go beyond low-Earth orbit into cislunar space, the region between Earth and the moon. That will be a proving ground in the 2020s. Then, we'll move into the neighborhood of Mars. Before we go to the Red Planet itself, we might want to go to one of its two moons. There's plenty to learn from landing there since the physics is different from here.

Because of orbital mechanics and the way Mars and Earth revolve around the sun, the two planets are nearest to one another for about 30 days, once every 26 months. That means the four- to six-member crew could stay on Mars a month, or they could stay until the next window, two years later. I think it makes sense to spend a lot of time on the surface because the trip is so long—seven months and 563 million km, give or take. We have 15 different tech road maps to get there. Because of the budget cycle, we can't afford big breakthroughs in all of them, so we're focusing on eight, including propulsion, entry, descent and landing, and life-support systems. And, of course, there's education.

For students today, Apollo is ancient history, yet they all want a selfie with the astronauts. The magic of NASA is that it still has a cool factor for young people. That's important because they're going to be the ones who actually set foot on Mars."

AS TOLD TO HEATHER HANSMAN

NASA

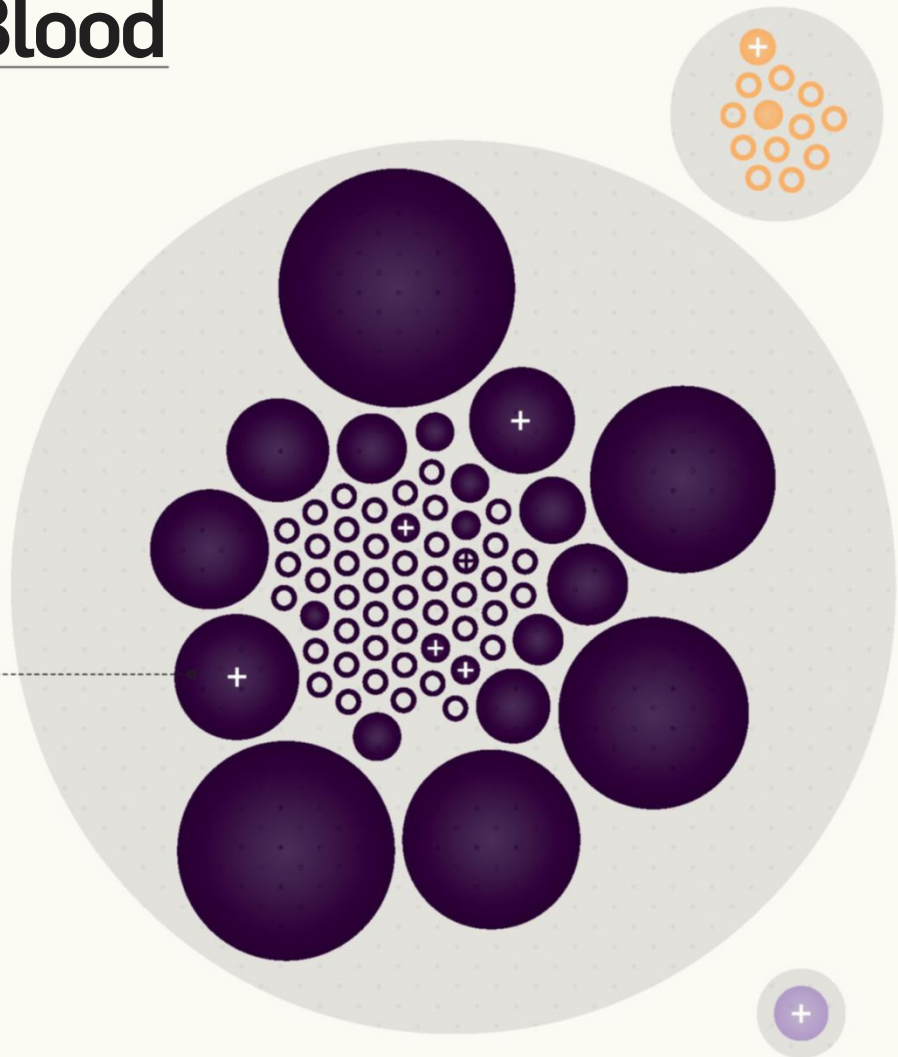
Your History in a Drop of Blood



A **blood sample** can now reveal a record of viruses you've had throughout life, thanks to a new test developed at Harvard called VirScan. It looks for evidence of antibodies produced by the immune system to kill viral invaders. "It's kind of like fishing," says geneticist Tomasz Kula. "We've made this huge pond [of viral bits], and we see which ones the antibodies stick to." Here are the viruses they found. **SHANNON PALUS**

SPECIES Human Herpesvirus 3
PREVALENCE 24 percent
TRAITS The source of chicken pox (and shingles)

Most people contract chicken pox before age 10 or get vaccinated to avoid it. Over time, the number of antibodies drops, so there could be too few for VirScan to detect (hence the low prevalence). This might also mean there aren't enough to fight off the virus if it comes back in the form of shingles during adulthood either.



HOW TO READ THIS VISUALIZATION

Each circle represents a virus tested for by VirScan. The researchers ran the test on 303 blood samples from U.S. subjects, excluding any known to be HIV- or Hepatitis C-positive.

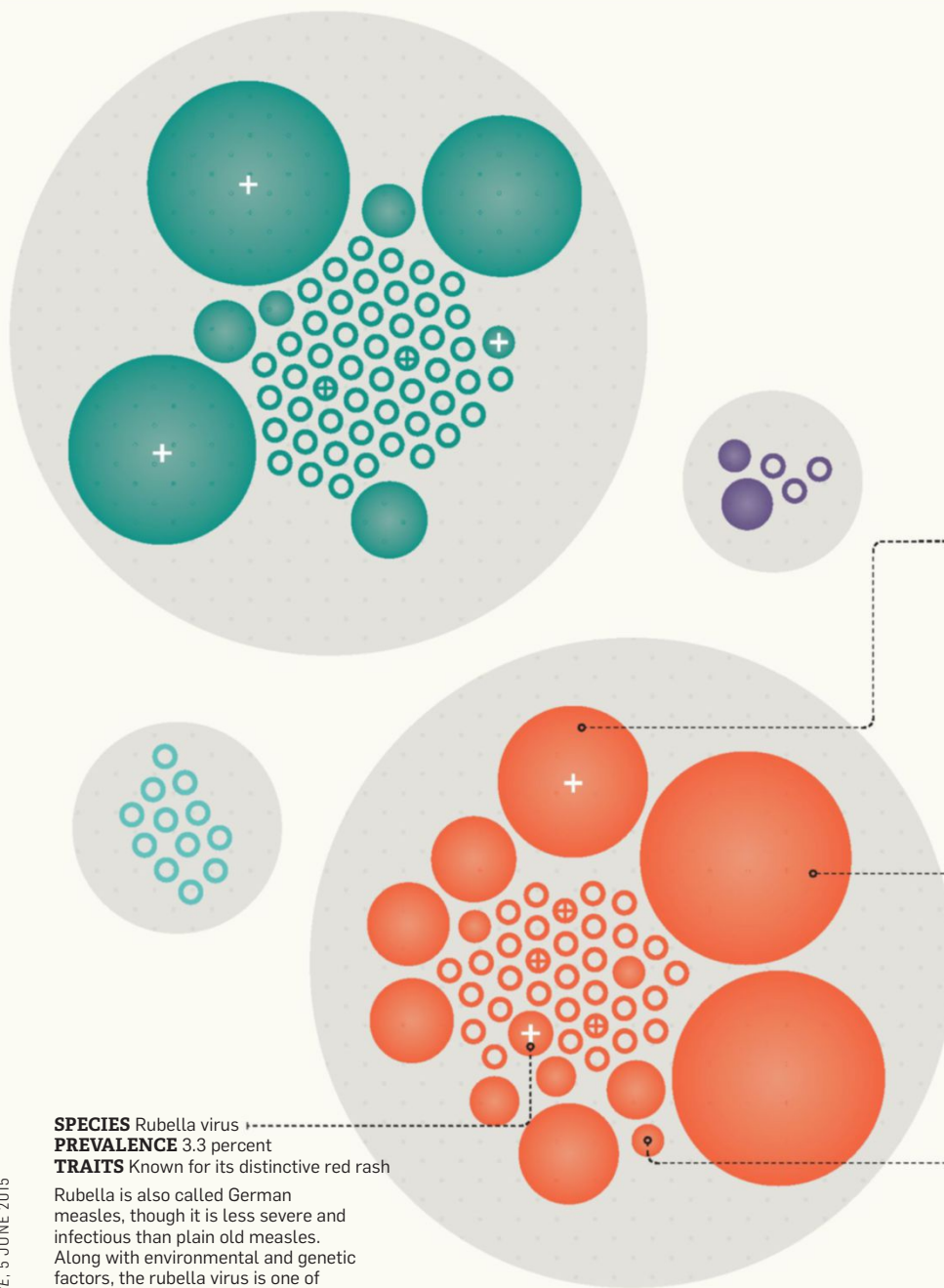


Circle size represents the prevalence, or the percentage of people who had antibodies from the virus present in their systems.

Plus signs mark virus species with FDA-approved vaccines

Colors indicate the virus class, which is based on its genome and how it multiplies.





HOW IT WORKS

VirScan matches antibodies in a person's blood sample to a library of 93,000 snippets of viral code. It can find evidence of up to 1,000 different viruses.

SPECIES Enterovirus C

PREVALENCE 37 percent

TRAITS Triggers polio, a disease the Centers for Disease Control and Prevention says has been absent from the U.S. since 1979

Vaccines during childhood usually prevent the disease, but the protection could fade over time. That's why you still need a booster to travel to one of the few remaining countries where polio still exists.

SPECIES Rhinovirus B

PREVALENCE 75 percent

TRAITS Responsible for the stuffy nose, sore throat, and sneezing associated with the common cold

Rhinovirus B is more prevalent in children than adults because it spreads by contact, so seemingly innocuous things like shared toys and drool-covered fingers become viral vectors.

SPECIES Hepatitis C virus

PREVALENCE 1.7 percent

TRAITS Causes Hepatitis C, an infection that is often symptom-free at first

Hepatitis C is not the most common virus, but it is a dangerous one because the inflammation and liver damage it causes can lead to liver cancer.

SPECIES Rubella virus

PREVALENCE 3.3 percent

TRAITS Known for its distinctive red rash

Rubella is also called German measles, though it is less severe and infectious than plain old measles. Along with environmental and genetic factors, the rubella virus is one of the candidates researchers think could cause multiple sclerosis.

FINDING WHAT AILS YOU

When you're sick, the symptoms need to suggest a particular virus, like the flu, for your doctor to narrow down what to test for. That's because most scans can look for only a single culprit. But some viruses, like Hepatitis C, can cause damage without any outward signs—meaning they can go unchecked for years. A routine VirScan could pick up on these and other rare pathogens so you can seek treatment.

92

Percentage of U.S. kids, age 19 to 35 months, vaccinated for measles, mumps, and rubella in 2013, according to the CDC

SOLVING MYSTERIES

Chronic fatigue syndrome affects more than 1 million Americans, but the cause is unclear. The CDC has a list of 10 suspects, seven of them viruses, including rubella and mononucleosis. By screening people with and without chronic fatigue, VirScan could collect enough data on their viral histories to determine if and how the viruses might be involved. Only then can researchers start looking into a cure.



For those who didn't read all 184 pages of the Pope's encyclical, here are the highlights:

Praise Be to Science

Science and religion usually make uneasy bedfellows. That's why Pope Francis' encyclical on climate change, published in June, made headlines. The papal essay is the Vatican's first authoritative word on climate policy, and it takes an unequivocal stance: The world needs to act.

Atmospheric scientist Katharine Hayhoe, director of the Climate Science Center at Texas Tech University, says the Pope's message might prove more effective than 30 years of scientists' efforts to communicate the urgency of climate change. "Scientists used to operate under the assumption that if people don't agree with you, it's because they don't understand," Hayhoe says. "So they thought, 'Oh, we just have to explain it better.'" But social scientists have learned that a simple lack of information doesn't explain disbelief or indifference. "Science can tell us why climate change is happening, and what might happen next," Hayhoe says. "But what we should do about it isn't a science question. It's a question of values."

And that's where Pope Francis comes in. He aligns the science of climate change with a moral call-to-arms. As he states in the encyclical, "Human beings, while capable of the worst, are also capable of rising above themselves, choosing again what is good, and making a new start." **LOIS PARSHLEY**

"It's morally irresponsible to suggest there's a debate about the reality of climate change."

—KATHARINE HAYHOE, DIRECTOR OF THE CLIMATE SCIENCE CENTER AT TEXAS TECH UNIVERSITY

1 CLIMATE CHANGE IS REAL

"Climate change is a global problem with grave implications: environmental, social, economic, political..." Francis writes. "It represents one of the principal challenges facing

humanity in our day." While there are still people who deny Earth is warming, the Pope echoes the consensus of the scientific community: Global surface temperatures have increased over the past 100 years. And it's our fault.

2 TECHNOLOGY WON'T SOLVE EVERYTHING

The Pope doesn't object to progress; he acknowledges that science and tech have enriched our lives, and provide us countless benefits. But he notes that advancements don't necessarily improve things across the board. "[O]ur immense technological development has not been accompanied by a development in human responsibility, values, and conscience."

3 WE HAVE TO CHANGE OUR BEHAVIOR

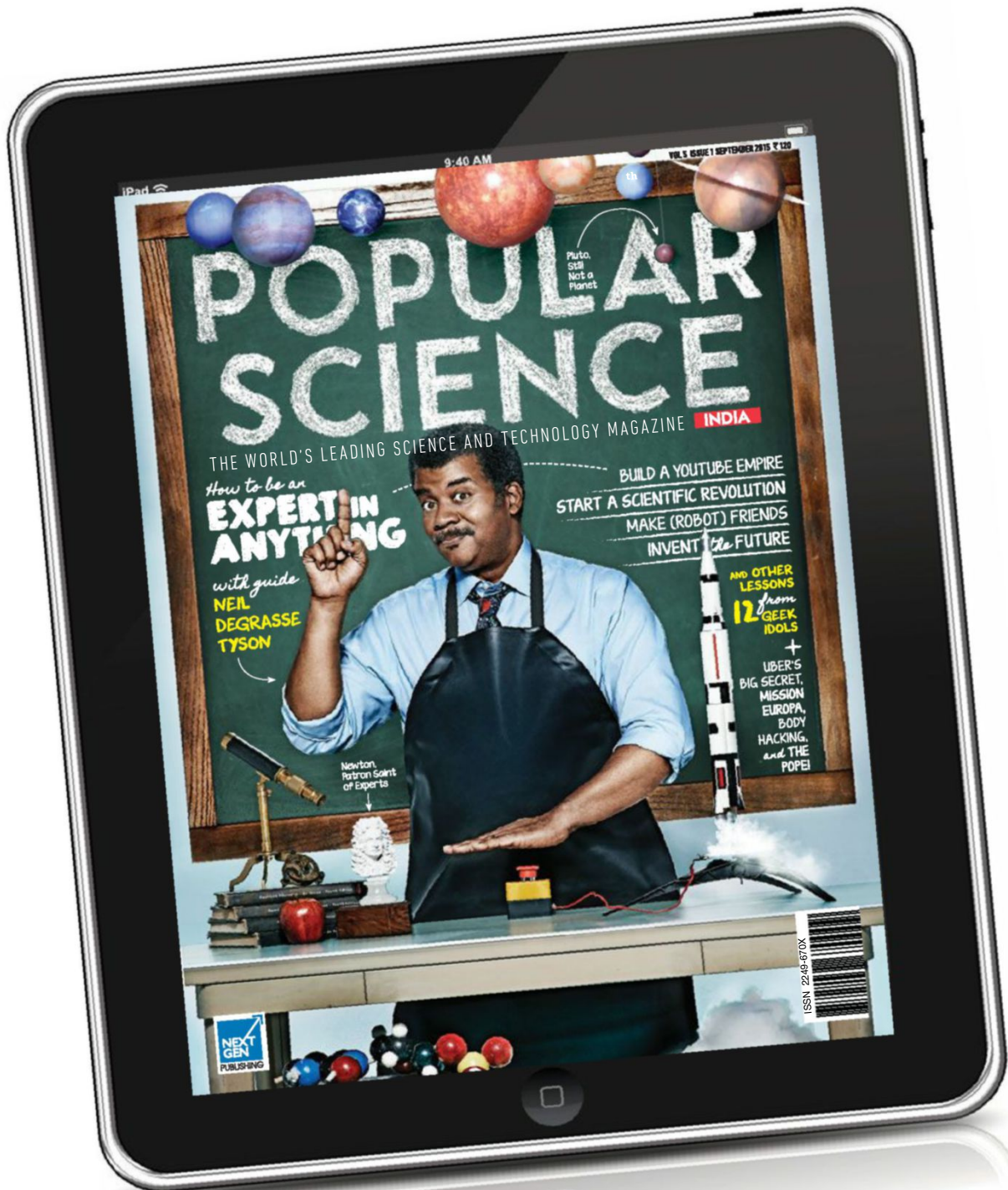
"An integral ecology is also made up of simple daily gestures which break with the logic of violence, exploitation, and selfishness," Francis writes. On a global scale, that could take the form of an international environmental treaty. "[R]ecent World Summits on the environment have not lived up to expectations because, due to lack of political will, they were unable to reach truly meaningful and effective global agreements on the environment." Here's hoping that the U.N. climate talks in Paris this December will be different.



6.7

Estimated average sea level rise, in inches, during the 20th century. The rate since 1993 is about twice that of the past century.

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Erik Sofge
James Vlahos



HOW TO BE AN EXPERT IN ANYTHING

NEIL deGRASSE TYSON

Host of *StarTalk*, director of the Hayden Planetarium

INTERVIEWED BY CLIFF RANSOM



To be an expert means you are on the frontier, making discoveries, thinking thoughts never before dreamed of. I'm an expert in astrophysics.

I don't generally share opinions. It may not feel that way because I speak passionately about what I know, but if you look at my tweets and books, I hardly ever express opinions—because I don't care if you have them. I don't care a rat's ass. As an educator and as a scientist, I care only that you are scientifically literate.

The more informed you are, the more empowered you are to think for yourself, and the more representative our democracy will be.

Don't come to me to debate whether climate change exists. If you're coming to me in that fashion, you do not understand how and why science works. You're expressing an opinion, and I'm expressing a fact.

Successful people are driven without regard to their social life, love life, the opinions of others. Every one of them has a story saying, "Here's a list of people who said I should do something safe."

To be genius is to be misunderstood, but to be misunderstood is not necessarily to be genius.

I am the consequence of my life experience. Everything that has happened to me has summed to be what I am. If I jumped back in time, I would derail that learning curve, so I don't have any urge to go to my younger self and say, "Do this, not that." What would that mean? Making mistakes contributes to your wisdom.

It's not that we fear technology, it's that we occasionally take it for granted, and when we do, we discount the brilliance and work that went into it. You'll say, "Oh, we don't need to increase the funding on science; I've got my smartphone. We don't need to go into space; I've got *weather.com*." Well, where the hell do you think you got the image of the hurricane that just tore up Galveston, Texas?

If you want a career in science and technology, well, you better hang out with some geeks. Go ahead. They are a friendly people. They're not talking about the clothing you are wearing. They're not talking about your waistline. It's just, "Who are you, and do you have interesting things to say?"

No matter what you do, you need to be able to fail and know how to recover from it in order to one day succeed. There is no successful person who has never failed. Think of the lessons you learn every time you fail. It's the people who ignore those lessons who basically check out of that contest permanently.

The fastest way to end a career in science and technology is if you're guilty of fraud. No one will listen to anything you publish thereafter. The greatest statement you can make to a scientist is to pay no attention to his or her science.

When you are first in the world to know something, there's nothing like it. There is no salary, there's no car you can drive to substitute for that feeling.

ONE OF MY FAVORITE LINES

COMES FROM POET
RAINER MARIA
RILKE: "BE PATIENT
TOWARD ALL THAT
IS UNSOLVED IN
YOUR HEART AND
TRY TO LOVE THE
QUESTIONS
THEMSELVES."



How to Build a YouTube Empire

FELICIA DAY, GAMER AND FOUNDER OF GEEK & SUNDRY CHANNEL

My name is Felicia Day, and I make Internet content. I guess that's the easiest way to put it. When I was 6 years old, my parents had a CompuServe account, which was one of the earliest commercial dial-up services. So my whole life I've been raised with the idea that you could connect with people online. When I took that first venture into filmmaking and saw people respond to it, I couldn't stop making videos no matter what barrier was in my way.

It was two years after YouTube's beta launch when I started uploading episodes of *The Guild*. It was a passion project about the world of gaming. We were crowdfunded before anyone even knew that was a thing. As a whim, I put up an ad on our website, and people gave us enough money to shoot again. We eventually started a company called Geek & Sundry, which makes dozens of Web series. A year ago, we sold the company to Legendary Entertainment, so now we're expanding to other platforms, such as Twitch, our own website, even television.

Honestly, were *The Guild* not successful, I still would have done it. That's the lesson I want to convey. We all have a unique perspective on life. If you look at the people who changed history, none of them tried to be like everybody else. Those peaks and valleys, the things that make you different, those are the things you should play into. The great thing about the Internet is that it's there to help you grow your weirdness. That's the way you're going to be exceptional in this world and get your voice heard—not by tamping it down.

How to Go the Distance

Nate Ballou, 95
America's oldest practicing nuclear chemist

Whatever your situation, make long-term goals and keep them in mind as the years pass, but also be open to all of life's opportunities. I've always been pretty focused on my research. I never felt distracted by extraneous things. But balance is important too. My wife and I have been married for 41 years. We landscape a lot. We also devote a couple of weeks to travel every year. Maybe that balance didn't help directly with my science, but it helped me to be a better person and therefore probably more effective in my science too.

“**YOU CAN'T TRY TO COPY SOMEONE'S SUCCESS. YOU HAVE TO BE TRUE TO YOUR WEIRDNESS.**”



HOW TO BIRTH THE NEXT SCIENTIFIC REVOLUTION

JENNIFER DOUDNA

Co-creator of gene-editing technique CRISPR, which allows scientists to repair disease-causing genetic mutations

I grew up in Hawaii and I had a great chemistry teacher in 10th grade, Ms. Wong. And Ms. Wong was very good at showing kids that science is not about memorizing facts in a textbook. It's about figuring stuff out. If you have a question, you can design an experiment to answer it. I found that really exciting. Experimental science is 90 percent about the things that don't work the way you think they will. It's being persistent in the face of facts. It's looking for connections others don't see. It's important to foster these skills in yourself if you want to do this job. You also need to work with fun, smart people. Science doesn't happen in a vacuum. In a lab, other people's enthusiasm and ideas inspire you. You might be stuck, trying to figure out “How do I do this experiment?” or “I don't understand the results I'm getting. What does it mean?” It's helpful to hear, “Oh, did you think about this?”

WHY DIY MATTERS

LIMOR FRIED

Founder of electronics-hobbyist company Adafruit

INTERVIEWED BY SOPHIE BUSHWICK



When I was about 7 or 8, I saw a bunch of balloons stuck to the ceiling at a local mall. No one could reach them, so I went home and constructed a mechanical arm. It was then, after going back and retrieving all the balloons, that I realized engineering was for me.

I decided early on that it's only work if you'd rather be doing something else. I really didn't want to wake up early and go to an office with a bunch of people telling me what to do. So I started selling the kits I made with a simple PayPal button on a website I built.

You can create a good business and a good cause, but only if you're willing and able to contribute something. For instance, I publish hundreds of free open-source repositories that help people make their electronics dreams come true. They also become customers. They become contributors. By making and sharing open-source hardware and software, we're putting value back into the system.

Tinkering, building, and sharing make a lot of great connections for people. There are tons of friends I've met because we were both tinkering on something and we found each other. I like bringing together as many different people as possible, solving interesting problems, and using technology to make the world a better place.

A DIY project teaches something more important than a skill like soldering or coding—it teaches problem solving. With electronics, you might need to rethink assumptions on how something physically works, or some code that needs rewriting. It's more than physical. It's more than digital.

Purchasing something isn't the same as making something—you have a more intimate relationship when you make something and share it. The physical things don't matter as much as the experience and the time you spend learning something or sharing that time with others.

My advice for aspiring DIYers who love tinkering but know nothing about electronics: Pick up an Arduino or Raspberry Pi and dive in—we have about 800 tutorials to get you started.

I don't really take vacations, but I do take days off. On Sunday, I took the day off and made a cellphone and GPS data logger that publishes my location to a new service we're working on called adafruit.io. I rode my bike 10 or so miles, and it worked out great. This week, I'll send the files off to the PCB (printed circuit board) house, and soon this will be a new product.

If I want to motivate a teenager to put down a smartphone and create something, I usually ask what's annoying to them. And they'll say that their parents or friends watch TV shows they don't like. So I'll suggest they build a TV-B-Gone kit—it's a fun and mostly harmless kit that, once built, turns off TVs. Nothing motivates a teenager like mischief.

People ask why I chose this hair color. It's apex predator pink. It chose me.

IF YOU WANT TO
CREATE SOMETHING
AMAZING

THERE ARE
PEOPLE OUT
THERE TO HELP
YOU. WE'RE ALL
INTERCONNECTED,
VIA THE INTERNET.
WE'RE NOT SOLO
ACTS ISOLATED IN
WORKSHOPS.





HOW TO CREATE YOUR FRIENDS

HEATHER KNIGHT

Social Robotician



I started building robots. Then I fell in love with them. At Carnegie Mellon University, I'm working with robot body language. People usually think of companion robots as ones that are just hanging out with you, as your friends or toys. I think they're essential for enabling the next generation of robotic machines. We want them to fit into our world, not for us to have to redesign ourselves.

Of all the classes I took in high school, the one that I think was most akin to creating robots was art. If you're making a sculpture, you come up with an idea and build it. If it falls over, you need to reconsider your construction. Like art, engineering is the process of thinking about something that hasn't existed before and building it. It's very creative. But social robotics is also rooted in human psychology. You have to make something that people can understand.

The emphasis on creativity will bring in more diversity. It's not just the diversity of gender and race. It's like revisiting the stereotypes of what being an engineer is to begin with. I was at the Three Rivers Arts Festival, and I gave a talk. A woman came up afterward and said: "I really have to tell my daughter about you. She's into ballet and art. And I'd love for her to be more into engineering, like you." Well, those don't necessarily have to contradict. Why can't she do them both together?



“
**YOU DON'T
NEED TO BE A
NERD TO BE AN
ENGINEER. YOU
DO, KIND OF,
BUT YOU DON'T.**

How to Motivate a Nation

Megan Smith
United States
Chief
Technology
Officer

For almost every problem we have in the world, there are people on this planet who have an idea, or a pilot, or a working solution. It is my job to discover and support them. Unfortunately, the country's talent networks are often divided geographically or racially. There's a bunch of underrepresented people in tech and innovation, often women and people of color. Yet, you can find extraordinary people if you look. The disaster-response community holds hackathons, where they do things like figure out how to use a car to charge cellphones. That's creative!



HOW TO (LITERALLY) BREAK INTO CODING

JAMES GOSLING

Father of the Java programming language

POPULAR SCIENCE: When did you start writing code?

JAMES GOSLING: When I was 13, we lived about 2 miles [3.2 km] from a university, and my dad's friend brought me to see the computer-science department. I was entranced. I just had to go back. But I was a long way from going to college. So instead, I got good at watching people punch the keys to the security doors. I literally started breaking in. **PS:** What did you do there?

JG: I was big enough that I was plausibly a university student, and I befriended a fellow who was working for the physics department. The department needed somebody to write software for PDP-8. I had already been teaching myself to program on it. So I ended up getting my first paying software job at 14 as a code monkey for a bunch of scientists trying to figure out how the aurora borealis works, which was so mind-explodingly fun.

PS: What about that other education you were supposed to be getting?

JG: High school was kind of a dubious thing for me. I ended up skipping a lot of classes. This was in the '60s, and there were a lot of drugs around; kids missed lots of school. But my teachers figured out what I was doing and covered for me.

PS: You later created Java at Sun Microsystems. Did you think it would take off?

JG: No. It was more like writing a science-fiction novel. But now there are some 10 million professional software engineers who use Java, and many more people know how to use it. It's even what the Advanced Placement computer-science course in high school is based on, which my kids study and get very grumpy at me about.



← Lindsey Hallen, Sierra Leone, March 2015

How to Face Fear

**LINDSEY HALLEN, HOSPITAL NURSE
EBOLA RESPONDER**

I work in an emergency room in New York City, and every day during the outbreak, we'd debrief about what to do if someone came in with Ebola. You could select if you wanted to work those patients. So I started thinking about it, and it became so obvious to me that help was needed in West Africa. So I decided to go.

I never second-guessed myself. I try to deal with fear in the most rational way possible. With the fear of getting sick, I made an educated decision that it was a risk worth taking.

In the hot zone, there was a young guy hooked up to an IV, and I had a short conversation with him through an interpreter. When we went back three hours later, I couldn't find him. I was about to leave when I realized he was lying under the bed. He was no longer alive. It looked like he had had a seizure. He was lying in a contorted position on the concrete floor. Even saying this to you...it's hard to process. It's just unacceptable that someone would have to go through that. It could have been prevented with the right resources.

The hardest part is wanting to provide so much more care. But we helped and it was important to go. Everyone has a thousand dreams, or thinks "Oh, it would be great if I could do that." No one is going to tell you to do something. I had to seek it out. I encourage people to do things others perceive as risky. If everyone had the courage to take chances, so many great things would come from it.

How to Market Greatness

Peter Thiel
Entrepreneur,
co-founder of
PayPal,
partner in
venture
capital firm
Founders Fund

I think great scientists and great inventors would do well to partner with great business people. One of the challenges scientists face is that they think the science is enough to carry the day. You come up with a breakthrough or an invention, and you think the world is going to beat a path to your door and beg to adopt it. Actually, it's always a challenge to turn even a great invention into something that consumers, or other businesses, will buy and use.



HOW TO PIONEER A NEW FIELD

WILLIAM BORUCKI

Former head of the *Kepler* exoplanet-finding mission; as of July, *Kepler* had identified 4,661 candidate exoplanets

I applied to just one place out of college, and that was NASA. I had always been interested in space exploration from reading science fiction when I was young. Many scientists and engineers at NASA read science fiction as kids, and that sort of opened up their imaginations to all sorts of possibilities. I knew that finding habitable planets would be an important first step in exploration. So I built an instrument that would allow us to search for them. Then I convinced NASA that we should fly a space mission with it on board. Funding for the research came through in 1983, but *Kepler* didn't launch until 2009. That's, I don't know, nearly 30 years. It takes a long time, but if you've got something you think is extremely valuable, extremely important, you should be willing to persevere. Sure, I felt frustrated, because year after year the answer was no. But I knew it would someday fly and be very, very important to NASA and to mankind.

“**I THOUGHT:
DO NOT BE
AFRAID. THIS
IS GOING TO BE
LIFE-CHANGING.**”



WHY GEEKS SHALL INHERIT THE EARTH

DEAN KAMEN

Inventor and entrepreneur, founder of FIRST Robotics Competition

INTERVIEWED BY JENNIFER BOGO



People used to say to me, I can't believe you quit school and risked everything to start a company. And I answer them: I risked everything I had because I had nothing.

Very early in my teens I decided to educate myself. I realized I was never going to be a very good student because I didn't like teachers judging me by what I thought were arbitrary standards. I decided I'd let the world judge me by whether I could do something of value—solve a problem or build something. And if people wanted it, they'd pay for it. And that's when I decided I'd be an inventor and entrepreneur.

I'd rather fail at trying to do something really big than succeed at being mediocre.

Start inventing as early as you can because, compared with most things, it's more likely to take you to places you can't predict and that you can't schedule and you can't budget for. Do all that when you can tolerate the insecurity.

Kids are full of imagination and much more willing to fail. Just watch a 3-year-old. They poke everything, and if it hurts they don't poke it again. They learn how to stand up and walk and talk, all at a breathtaking rate. Try to teach an adult a foreign language.

School frequently isn't testing whether you understand something but whether you're familiar with it. What's Newton's second law? You say $F=ma$, and you get an A. That does not reflect a deep understanding of Newtonian mechanics, or electrodynamics if it's Maxwell's equations, or thermodynamics if it's the first or second law. That the integral of dQ over T is entropy is a nontrivial thing to understand.

FIRST is an unabashed success: about 40,000 teams, in 80 countries, competing in engineering contests, including an extremely popular robot-building challenge. It has 125,000 volunteers and 3,500 corporate sponsors. Everybody is hugely proud of it. But by the standards of our culture, compared with the Super Bowl or a big rock concert, I'm dismally disappointed. I always believe that by next year it'll be so obvious what a great thing this is that it will be available to every kid on the planet.

The Bible said the meek shall inherit the earth; I personally think it's the geek who shall inherit the earth.

We should embrace all those people who don't get geeks and make them part of our culture. Because a world that has only a few geeks, and those geeks are not leading the rest of the world in the right direction, is going to be an ugly world.

I would say to all these kids, "Keep it up, and although it's tough work and sometimes you fail, and sometimes people might take shots at you when you do fail, don't let it bother you."

If you're lucky enough to understand and appreciate tech, you've got to spread that wealth. You've got to get more kids capable of being part of a future in which the world will be prepared to solve its ever more complex problems. 

WHEN'S THE RIGHT AGE TO BECOME AN INVENTOR?

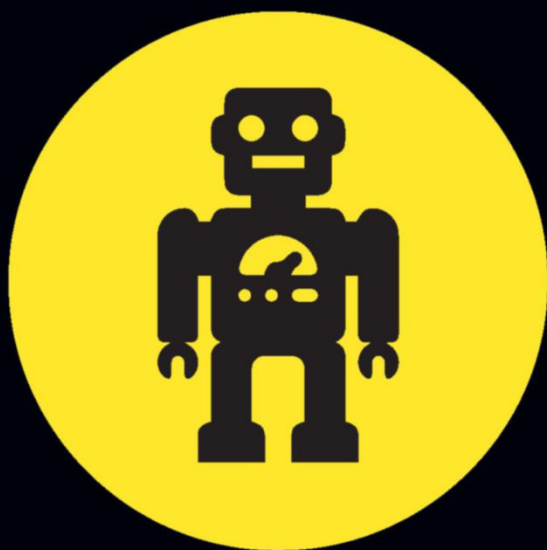
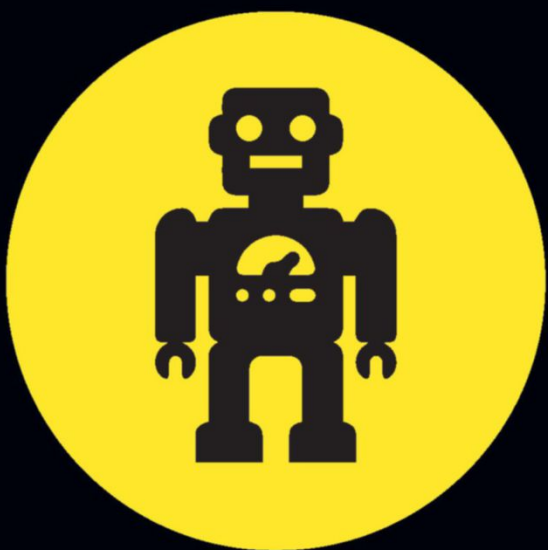
I'D SAY IN THE WOMB. SERIOUSLY, KIDS DON'T HAVE BRED-IN ANXIETIES ABOUT TRYING TO AVOID FAILURE. THE YOUNGER, THE BETTER.



Uber Powerful

The car-service startup has a brazen plan to become a robotic superpower. Should we be excited or afraid?

BY ERIK SOFGE





This past spring, two engineers huddled behind computer monitors as they fine-tuned a robotic ape. The 200-kg simian-inspired machine, called Chimp, would soon be competing in the Pentagon-funded DARPA Robotics Challenge. The competition to build disaster-response robots, which had started three years before, was nearing its final showdown. And Carnegie Mellon University's Chimp was considered a front-runner for the top prize of \$2 million.

But as Chimp went through its paces, the rest of the robots in the university's cavernous National Robotics Engineering Center sat unattended. The center was typically a flurry of activity, with engineers hunched over terminals tethered to all manner of autonomous machines, including mowers, harvesters, excavators, and combat vehicles. Now, in the middle of a weekday, the lab—part of the biggest robotics program in the country—seemed abandoned. It looked more like a museum closed for renovations.

What happened to NREC? In a word: Uber. The San Francisco-based firm is an exemplar of Silicon Valley success, having reportedly raised \$2.8 billion in funding on the strength of a single car-service app. Now Uber is racing to build self-driving cars. No longer content to take on traditional taxi companies, Uber hopes to use robots to lower fares, and ultimately compete with the entire automotive industry. "When there's no other dude in the car," Uber CEO Travis Kalanick said at the Code Conference in 2014, referring to the service's human drivers, "the cost of taking an Uber anywhere becomes cheaper than owning a vehicle...and then car ownership goes away."

This past February, the company announced a strategic partnership with Carnegie Mellon University (CMU) to develop the vehicles at the

1.



new Uber Advanced Technologies Center in Pittsburgh, temporarily located just a short stroll from NREC. Not announced was how Uber staffed up its center: by quietly siphoning personnel away from its partner. (Neither Uber nor CMU would comment on this.) By the time we visited, the startup had hired 40 or 50 of NREC's roughly 150 researchers, including Tony Stentz, the roboticist who had served as the center's associate director for 13 years and director for nearly five.

"Uber was incredibly smart in that it went to the one place, outside Google, that has all of the right people—people who actually have a shot at tackling autonomous driving," says Boris Sofman, who studied robotics at CMU and had Stentz as an adviser. Like many CMU grads, Sofman went on to found his own startup, Anki, which makes autonomous toy cars.

Carnegie Mellon has long been a leader in robotics. It was the first university to offer a doctoral program in the discipline. Its contracts to commercialize robotic technologies at NREC routinely pull in an estimated \$20 million annually. And its researchers pioneered robotic cars, winning the DARPA Urban Challenge with a driverless Chevy Tahoe in 2007. When Google started its self-driving-car program, it dipped into CMU too. "It's not because we're good; it's not because we're smart," says William "Red" Whittaker, director of CMU's Field Robotics Center. "It's because, my God, we started so early, and we were so strategic, and we built an army."

But when a third of your army decamps in the night, including its colonels, questions are inevitable. The most important one is this: What does the plunder of a leading research institute mean for the future of robotics?

Like most scientific pursuits, robotics thrives on collaboration across teams and projects. But as the field enters a new era of funding and interest, many of its most talented engineers are being cloistered out of sight. Amazon and Apple have been amassing in-house robotics teams, and keeping their work largely under wraps. Uber has asked its new hires to sign nondisclosure agreements. And when Google acquired eight promising robotics firms in late 2013, those companies immediately stopped discussing their research. One of those acquisitions, a Japanese startup called SCHAFT, built a humanoid S-One robot that dominated the first phase of the DARPA Robotics Challenge. Google pulled SCHAFT from the competition in early 2014, and S-One hasn't been seen since.

Until Silicon Valley starts churning out actual robots, some think its newfound interest could hinder progress in the field. "I've been party to conversations in the upper crust of the research world," Whittaker says. "The language that's been used is the threat of a research drought. This vast, amazing talent is picked off in such a way that it takes a guy like me 10 years to make them, and an instant for them to disappear."

Rich Mahoney, director of robotics at SRI International and president of



3.



1. Carnegie Mellon's Chimp uses machine perception to navigate its environment—just as an autonomous car might.

2. A few months after Uber opened its Advanced Technologies Center in Pittsburgh, a research vehicle was seen roaming the city's streets.

3. Uber's CEO, Travis Kalanick, said that cutting out human drivers will make his service cheaper than owning a vehicle.

the Silicon Valley Robotics industry group, argues that innovation is being smothered in the private sector. "There are hundreds, literally hundreds, of roboticists in Silicon Valley—extremely talented people—who are not engaged in the robotics community," he says.

The newly cash-infused state of robotics has been compared to the early days of computing. Scrappy startups like Apple and Microsoft innovated themselves into positions to rival established players such as HP and IBM. What's changed is that now firms like Google and Uber are pre-empting the development of a thriving startup scene by sucking up roboticists in large numbers. "Who are the visionary early-stage leaders?" Mahoney asks. "Who's the Bill Gates and Steve Jobs of robotics? These companies have so many resources available that they can just go out and hire a block of talent. If they align that talent with the right products, they can do something really special. If they don't, they're just taking these players out of the market."

While it would be easy to view CMU's loss of talent as a casualty of Silicon Valley's rapacious self-interest, most roboticists see it as affirmation.

"There's a brain drain from academia to industry right now," says Vijay Kumar, a roboticist at the University of Pennsylvania and former director of the school's GRASP Laboratory. "But if the direction of the brain drain were the other way, that means we're in the wrong field."

Earlier this year, Qualcomm Technologies acquired KMe Robotics, a startup spun out of GRASP Lab in 2011 that specializes in autonomous drones. Though the terms of the deal haven't been disclosed, Kumar described the payout as "an ungodly amount of money." Qualcomm is also spending \$1 million on a four-month robotics accelerator program that culminates this fall. "I love the attention that the field is getting," Kumar says. "I love that my colleagues and my students are being attracted by the Googles and the Qualcomms and the Ubers. The more interest that industry shows in the field, the more people will realize that to make a complete product, you need more basic research investment."

There's no question that the private sector can free roboticists up to do more, quicker. "The average professor will spend 50 percent of their time just writing grant proposals, trying to justify the research they want to do," says Anki's Sofman. Despite the promise of the DARPA Urban Challenge, it wasn't until Google hired roboticists and started field-testing autonomous cars that robot vehicles gained real momentum. Academia may have given

birth to self-driving cars, but it was a corporation that set them loose in Bay Area traffic.

"It's insufficient to just write research papers," says Sebastian Thrun, a professor at Stanford University's Artificial Intelligence Laboratory and founder of Google's self-driving-car project. "At the end of the day, these products need to be built and brought to market to be impactful." Thrun is perhaps more familiar with this issue than any roboticist, having worked as an associate professor at CMU before joining Stanford in 2003, and then switching to a full-time position at Google from 2011 to 2014. Though the scale



of Uber's recruiting drive surprised him, Thrun isn't concerned by it at all. "I think it's a sign of confidence, that the age of robotics has begun."

Most in the field share Thrun's opinion: that robotics has reached an inflection point. In addition to the recent headhunting and spate of acquisitions, venture capital has been flowing into the small outfits that haven't yet been scooped up. Firms

invested an estimated \$341 million in robotics in 2014 alone. That's tiny compared with other tech sectors, but it's up from 2013 by more than a third.

As of press time, Uber still had job openings for 24 different types of engineers at its Pittsburgh research center. And a vehicle testing systems for its future self-driving car had already been seen on city streets. NREC, meanwhile, isn't in what *The Wall Street Journal* called "a crisis." The lab is hiring to fill vacant slots and actually expanding, adding new positions and seeking new contracts. Silicon Valley will be back and, like other universities with acclaimed robotics programs, CMU has to view its inevitable future personnel losses as victories for the field.

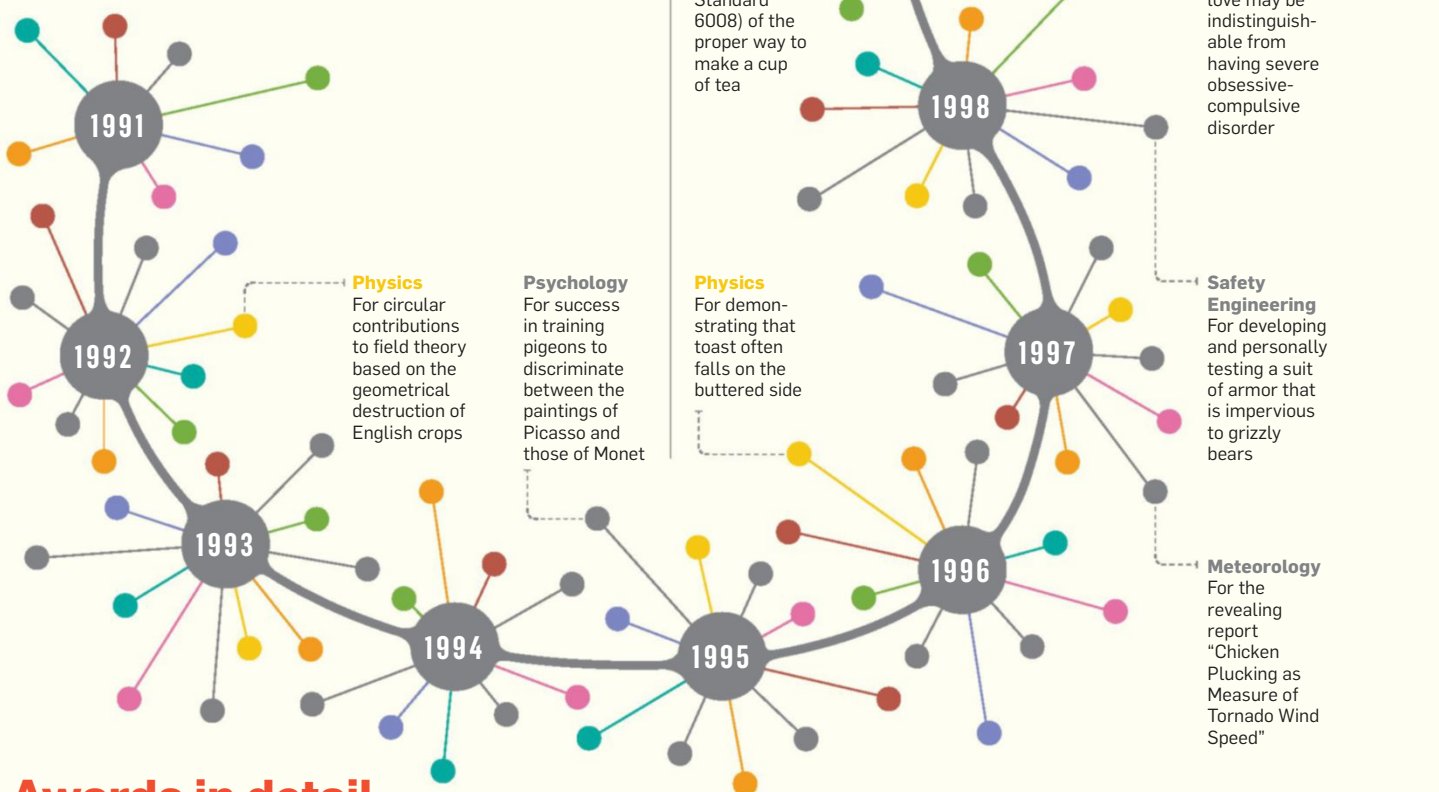
"The only metric of a technology is the extent to which it gets out there in the real world, impacts life, and generates wealth," Whittaker says. "I haven't spent a lifetime creating this stuff for it to gather dust in a basement." 🚗

"UBER WENT TO THE ONE PLACE, OUTSIDE GOOGLE, THAT HAS ALL OF THE PEOPLE WITH A SHOT AT TACKLING AUTONOMOUS DRIVING."

The Less-Noble Nobels

An annual tribute to science's funniest research celebrates its 25th year

↓
In 1990, as editor of a science magazine, Marc Abrahams encountered plenty of important research. He also saw lots of science that was just plain hilarious—but those researchers remained obscure. “So,” he says, “we began to celebrate them.” He held the first Ig Nobel awards in September 1991. In the decades since, the ceremony has honored research that probes why woodpeckers don’t get headaches, and whether humans swim faster in syrup or water (it’s a wash). It’s work that lives up to the Ig Nobel tagline: “Research that makes people laugh and then think.”



Awards in detail

Chemistry, 1994

A Texas state senator earned an Ig Nobel for requiring permits to purchase laboratory glassware—one of many times the committee has used its position to spotlight people who hinder science. But just as often, scientists themselves are skewered: In 1993, the literature prize went to all 976 authors of a 10-page biology paper.

Biology, 1999

A spiceless jalapeño might seem like an oxymoron, but a horticulturalist at the Chile Pepper Institute of New Mexico State University was recognized for developing one. The pepper allows a chef to create a salsa that’s mild but still tastes like jalapeños.

Biology, 2004

Two teams won prizes for discovering that herring communicate underwater by emitting gas—that is to say, by farting—at a rate that creates an audible chirp. According to Marc Abrahams, the research diffused an international incident: The Swedish government had initially assumed the chirp was from Russian spy submarines.

Mathematics, 2006

The honor went to a pair of researchers who calculated how many group pictures you must snap for everyone’s eyes to be open in at least one. Their rule of thumb? For groups of 20 or fewer, divide the number of people by three, and take that many photos.

Notable laureates

Theodore Gray

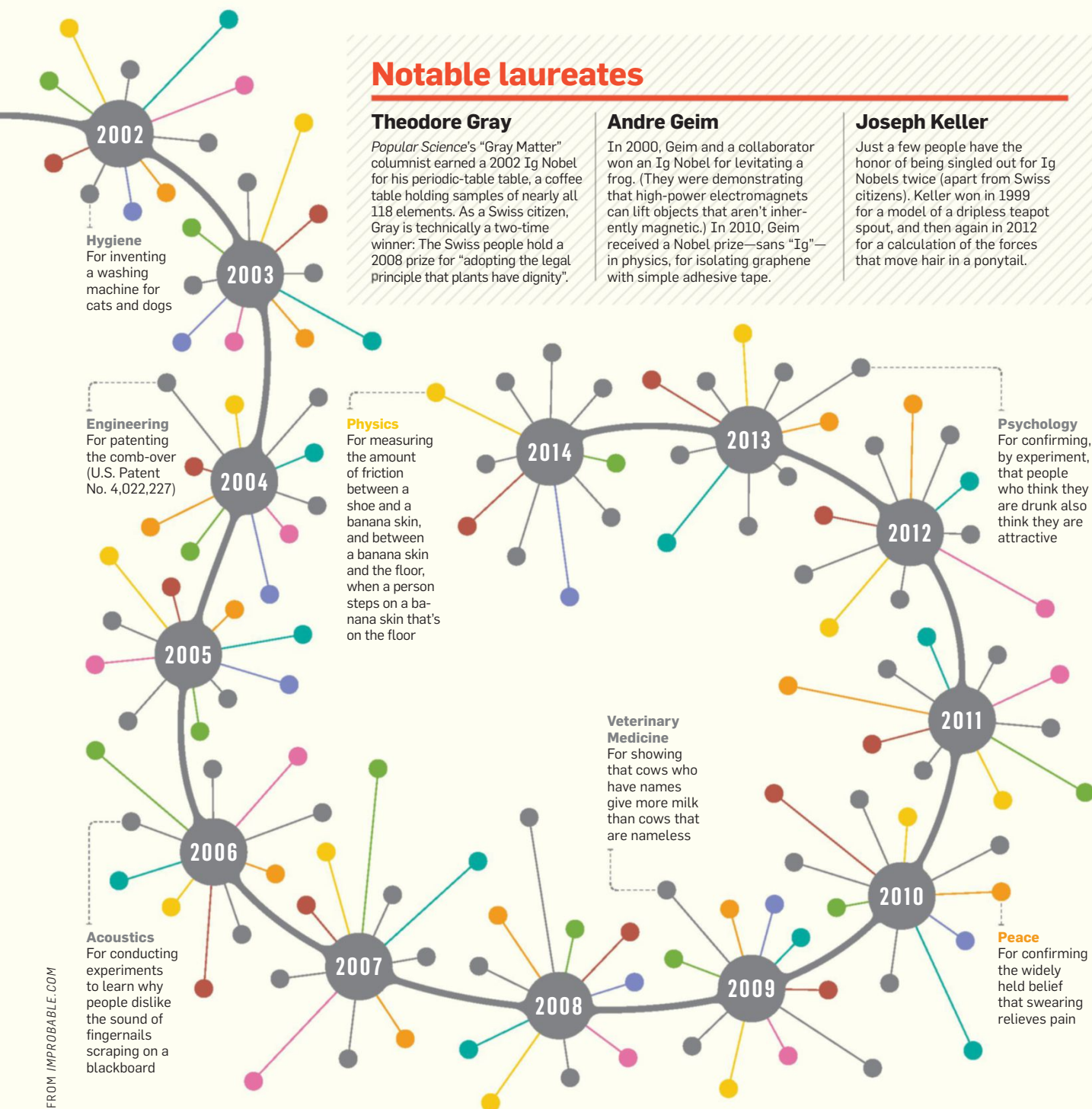
Popular Science's "Gray Matter" columnist earned a 2002 Ig Nobel for his periodic-table table, a coffee table holding samples of nearly all 118 elements. As a Swiss citizen, Gray is technically a two-time winner: The Swiss people hold a 2008 prize for "adopting the legal principle that plants have dignity".

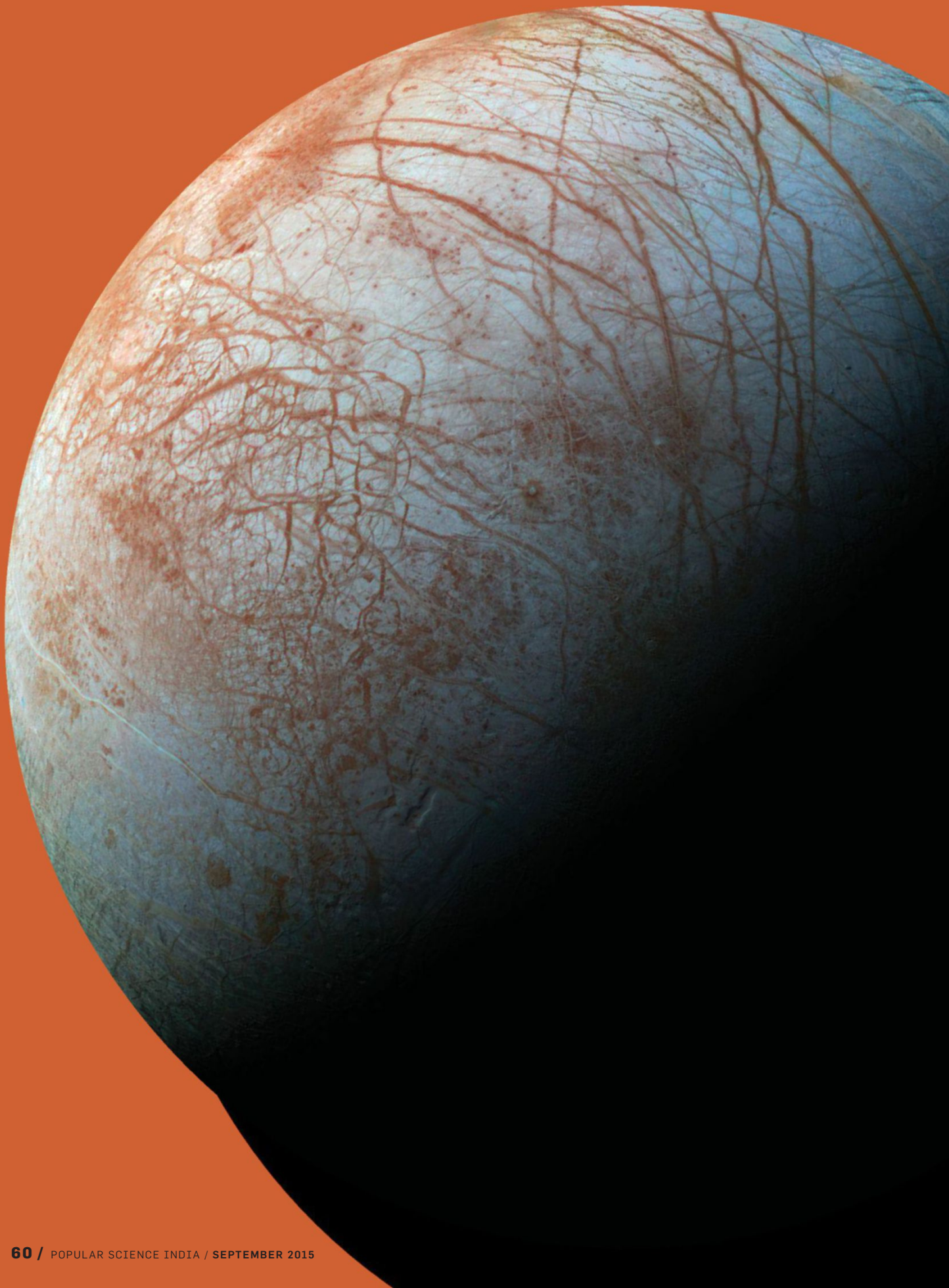
Andre Geim

In 2000, Geim and a collaborator won an Ig Nobel for levitating a frog. (They were demonstrating that high-power electromagnets can lift objects that aren't inherently magnetic.) In 2010, Geim received a Nobel prize—sans "Ig"—in physics, for isolating graphene with simple adhesive tape.

Joseph Keller

Just a few people have the honor of being singled out for Ig Nobels twice (apart from Swiss citizens). Keller won in 1999 for a model of a dripless teapot spout, and then again in 2012 for a calculation of the forces that move hair in a ponytail.







EUROPA

JUPITER'S OCEAN-FILLED MOON MIGHT HOLD THE LIFE WE'VE LONG SEARCHED FOR IN SPACE. AND SCIENTISTS HAVE ONE SHOT TO REACH IT.

OR BUST

BY COREY S. POWELL

The search for alien life has recently taken a surprise twist away from Mars and toward Europa, an ice ball of a moon in orbit around Jupiter. To understand why, you just need to look at these three numbers:

ZERO

1.33 BILLION

3 BILLION

The first is the volume of known water on Mars (sorry, permafrost and billion-year-old riverbeds don't count). The second is the volume of water on Earth, measured in cubic kilometers. The third is the inferred volume of water sloshing around just beneath Europa's frozen surface. Sure, Mars may have had oceans billions of years ago, but Europa has them right now—and they are more than twice as large as all of Earth's oceans combined.

Everything we know about life says that it needs water. Conversely, every place on Earth where water exists, life does too. The conventional thinking, then, is that if you want to find alien life, the first thing you look for is alien water. Europa is the wettest-known world in the solar system. Life also needs food and energy. Europa scores there too: Its ocean might be nourished by a drizzle of organic chemicals and stirred by volcanic vents like the ones dotting the mid-Atlantic ridge. If any place in the solar system holds the answer to the "Are we alone?" question, it's a good bet that Europa, not the Red Planet, does.

Which is not to say that getting the answer will be easy—not by a long shot. To give you a sense of exactly how hard it will be, consider three more numbers: 965 million—the average flight distance, in kilometers, from Earth to Europa, meaning that the journey there could take at least six years; 500—the average radiation dose, in rem per day, on Europa's surface, enough to fry unprotected spacecraft electronics within a matter of days; and 16—the average estimated thickness, in kilometers, of Europa's

ice shell, more than four times as thick as the glaciers covering Antarctica. Overcoming those numbers will test the limits of human ingenuity. But a growing chorus of scientists has argued that we must try.

This past May, NASA finally agreed and began the development of a probe to visit Europa sometime in the next decade. Many details of the mission, including its name, are still up in the air. But NASA has selected the nine scientific instruments that will ride aboard the craft to collect data, and Congress has put up the cash to get the potentially \$2 billion project underway.

For the Europa faithful, this news has prompted celebratory toasts, along with more than a little giddy disbelief. "We understand how special Europa is. It's worth the investment. It's worth the risk," says Louise Prockter, a planetary scientist at Johns Hopkins University's Applied Physics Laboratory. Prockter has already made that investment herself, having spent half her career studying Europa's unique, frosty terrain. "I just hope we can get something there while I'm alive."



This close-up of Europa, taken by *Galileo* in 1997, has been color-enhanced to reveal surface features. Blue-white terrain shows relatively pure water ice; reddish stripes may contain salts from an ocean.

SOMETIMES GREAT discoveries begin with what you do not see. Such was the case when *Voyager 2* flew past Europa in 1979. It radioed home images revealing a world as white as a glacier, slashed with enigmatic brown streaks, and utterly flat. “No craters. It just looked like a huge ice pack. That was a big surprise,” recalls Ed Stone, *Voyager*’s long-serving project scientist. A lack of craters indicated a fast-changing surface that quickly erases the scars of asteroid impacts; that, in turn, implied that there must be some unrecognized energy source driving the activity. We know now that Europa’s gravitational interactions with Jupiter’s other large moons stretch and squeeze its interior, producing frictional heat (akin to rubbing your hands together) and creating a vast, warm ocean. The ice pack is merely frosting on top.

Three years after *Voyager*’s flyby, the writer Arthur C. Clarke was so captivated by the discovery that he set his novel *2010* on Europa. He imagined it as a world inhabited by primitive aquatic creatures and guarded by the monoliths from *2001: A Space Odyssey*. They issued a warning to humans: “All these worlds are yours—except Europa. Attempt no landing there.” Among planetary scientists, these words have become both an in-joke and a taunt.

In 1995, NASA’s *Galileo* spacecraft went into orbit around Jupiter, and Europa came into sharper focus—up to a point. A series of new, much-closer images showed the

moon’s streaks appear to be glacial fissures that have been flooded from below. Other regions resembled sea ice that has broken apart and refrozen. But *Galileo* was hobbled by a faulty radio antenna that restricted its data transmissions to a trickle. Over much of Europa it was unable to capture any details less than roughly 1 mile wide, and the probe left some regions almost entirely unmapped. No other spacecraft has gone to visit since the *Galileo* mission concluded in 2003.

Prockter has made the best of a difficult situation, meticulously knitting together the two-decade-old imagery to show that Europa’s surface ice circulates down to the warmer layers below and back up—a colder version of Earth’s plate tectonics. Britney Schmidt, an astrobiologist at Georgia Tech, has found evidence of Lake Erie-size bodies of water embedded within Europa’s crust that could act as conduits between ocean and surface. Taken together, these discoveries point to an intriguing model. As the crust slowly churns, the surface ice could transport oxygen, minerals, and organic chemicals deposited by comets into the ocean’s depths. Meanwhile, upwelling ice or rupturing lakes might carry evidence of life to the surface. “If we can really understand how the ice shell works, that will tell us about Europa’s ability to support life, about where to look,” Schmidt says.

Recent long-range studies have added to Europa’s mystique. Nearly two years ago, researchers working with the Hubble Space Telescope sighted a huge vapor cloud hovering over Europa’s southern hemisphere. Evidently liquid water is able to break through the crust and blow into space, meaning that either

If any place in the solar system holds the answer to “Are we alone?” it’s a good bet Europa does.

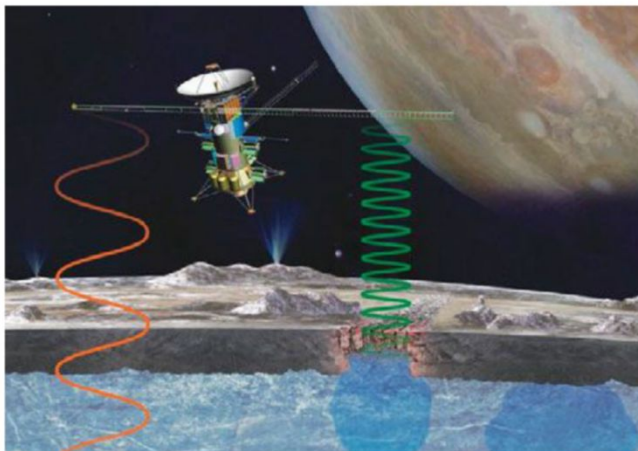
there is water close to the surface or there are very deep cracks in the ice. Also, this past May, a team at NASA's Jet Propulsion Laboratory (JPL) reported on experiments that reproduced the red-brown color of Europa's streaks: The markings seem to be the result of oceanic salts that reached the surface and were discolored by Jupiter's radiation. A salty ocean is just what you'd expect if water interacts vigorously with a rocky seabed, picking up dissolved salts. And well-stirred mineral-rich waters bode well for life.

All of which would make Europa a fascinating destination even if it were a freaky outlier, but it isn't. Broadly similar icy worlds—including moons, dwarf planets, and giant asteroids—are the norm in the vast outer zone of the solar system. According to the latest research, at least nine of these bodies have inner oceans too. Even Pluto might be wet on the inside, a suspicion bolstered by the 11,000-foot ice mountains and other dramatic surface geology recently found by the *New Horizons* probe. Put another way, most of the liquid water in the solar system is found not on the surface of rocky worlds like Earth but inside icy bodies like Europa. That raises the stakes for NASA's upcoming mission. If we find evidence of life on Europa, it would point to a whole new class of habitable worlds across the solar system, and probably across the universe.

PRETTY MUCH FROM the moment *Galileo* reached Jupiter 20 years ago, Europa proponents have been thinking about how to go back and study the moon in proper detail. Along the way, they have worked on three separate mission concepts that NASA initiated and then canceled. At this point, they know the challenges of Europa backward and forward.

Distance is the simplest one to address because it has a straightforward, brute-force solution. Using an off-the-shelf Atlas V rocket, the voyage to Europa would take at least six years—a painfully long time for academics and political supporters alike. The current Europa concept therefore calls for hitching a ride on NASA's upcoming rocket, the giant Space Launch System (SLS). In its initial configuration, SLS will be 321 feet tall and pack 8.4 million pounds of thrust. That's good enough to potentially cut the travel time to Europa at least in half. In NASA's current schedule, the first SLS will be ready for a test flight in 2018—plenty early for a Europa mission, which is provisionally slated for launch in 2022.

Dealing with radiation is trickier. An earlier Europa mission concept included a heavily shielded orbiter that was designed to survive the nonstop barrage of energetic



The Europa probe will carry a radar that emits both short and long wavelengths. These will penetrate the moon's shell to measure the ice and detect pockets of water.

particles near Jupiter. Partly for that reason, the probe was estimated to cost a hefty \$4 billion-plus. A team including Robert Pappalardo of JPL came up with a simpler, cheaper solution: Ditch the idea of orbiting Europa and instead settle into a straightforward orbit of Jupiter as a whole. As the probe whirls around the giant planet, it will fly past Europa about 45 times, skimming as close as 15 miles above the surface. After each pass, it will quickly retreat to a more distant part of its orbit, where radiation levels are drastically lower. The team estimates that the cut-and-run approach will easily allow the probe's electronics to survive the intended three-year duration of the mission.

But radiation creates an informational challenge in addition to the physical one. Even if there is life on Europa, and even if circulation of the ice sometimes carries ocean organisms to the surface, Jupiter's magnetic field blasts them with energetic particles as soon as they are exposed. Those particles break down organic molecules, so it would be difficult to detect intact traces of alien microbes lying on Europa's surface. (A beached European whale? Maybe. But nobody is banking on that.)

Fortunately, Europa itself has provided a solution. The icy plumes might eject water samples as high as 125 miles above the surface—well within the probe's flight path. A group of scientists recently convened a workshop called "Potential for Finding Life in a Europa Plume" to figure out how to take advantage of this discovery. Forget about finding intact microbes, they concluded. Even if Europa's ocean waters are as rich with life as Earth's, the odds of

scooping up a living cell are minuscule. Oh, and the craft will be moving about 10,000 mph relative to the plume; any bits of ocean, and any organisms in it, will hit at six times the speed of a bullet from an AK-47.

The researchers are optimistic

Any bits of ocean or organisms will hit the probe at six times the speed of a bullet from an AK-47.

Our Watery Neighbors

Where there's water, there's the possibility of life. And a surprising amount of water can be found throughout the solar system. Scientists have now identified at least nine worlds other than ours that likely harbor warm inner oceans.



CERES

Nearly 25 percent of the dwarf planet is made up of water ice, and a fraction of that could be liquid.



EUROPA

There is strong evidence of a salty, circulating ocean just beneath this Jovian moon's ice shell.



GANYMEDE

Jupiter's biggest moon may have saltwater inside; a 2022 European probe plans to investigate.



CALLISTO

Under a 96.5-km-thick crust, this Jovian moon may have an ocean deeper than any on Earth.



ENCELADUS

Jets of water seen on Saturn's moon Enceladus seem to be fed by an ocean under its south pole.



TITAN

A salty ocean lurks inside Saturn's largest moon; up top, there are lakes of liquid natural gas.



MIMAS

Another moon of Saturn, Mimas hides either a subsurface ocean or a football-shaped core.



TRITON

The features on Neptune's moon Triton imply it may have had an ocean—but possibly no longer.



PLUTO

New Horizons spotted geologic activity on the dwarf planet that might be driven by an inner ocean.

all the same, for two reasons. First, finding chemical signatures of life is far easier than finding an intact alien bug. With that in mind, a pair of miniature labs aboard the probe will aim to measure the composition of the plume as it flies through. Second, it might be possible to spot flash-frozen, life-bearing seawater (or at least life-friendly chemistry) on the European surface before it gets irradiated beyond recognition. The probe will carry a radar to seek out regions of thin ice, where eruptions might have occurred in the recent past, and a device called an imaging spectrometer to scan the surface composition in detail.

In the end, though, Europa's plumes might give merely

circumstantial evidence. The better way to get answers—the one that puts a gleam into the researchers' eyes—is to ignore Arthur C. Clarke's monoliths and send a lander.

WHAT WE WILL FIND if we touch down on the surface of Europa is anyone's guess. Humans have never landed on an ice world before. The closest analogs are the Earth's Arctic and Antarctic regions, but in many ways the resemblance is only superficial. Pappalardo points out that Europa is far colder, with highs never rising above minus 99 degrees Celsius. At those temperatures water is as hard as concrete and produces novel forms of ice geology. Radiation erodes the surface in unpredictable ways. In short, we have almost no idea what kind of surface we'd be landing on, or what we'd see once we got there.

Adam Steltzner, the JPL engineer whose team designed the insane-genius "skycrane" landing system for the Mars *Curiosity* rover, is ready to design a Europa lander all the same. He notes that the engineers didn't know the surface landscape of Mars when the Viking landers descended in 1976, and they did just fine. Touching down is, literally, just a matter of rocket science. "It's how much weight you can carry," he says, "how much power, how big of a retro-rocket." If you want the lander to last more than a few days, you also need a lot of radiation protection. The heavier the lander, the bigger the thrusters you need to go from 19,308 kmph in orbit to 0 mph on touchdown. And you'd need the primary orbiter to scout out good sites before releasing the lander. Hard jobs, but there are no showstoppers from the engineering side.

Steltzner already has some clever ideas about how the lander might go about its scientific work. Extracting samples from the frozen European surface would not require a costly power drill, he notes; the lander could do the job more elegantly by using its onboard power supply to run a heater in one of its legs. A little warmth would be enough to melt and vaporize the underlying ice. Then the lander could suck the fumes up through the leg, draw them through a mini chemistry lab, and look for signs of life. As the lander settles it would perform a tiny excavation, burrowing through the irradiated surface into the more-intact ice below.

NASA has also invited the European Space Agency to submit a proposal for a Europa lander or a high-speed ice penetrator—basically a javelin thrown into the ice. Any of these ideas would have to go through a review process, and probably would not be formally approved until 2016 or 2017. There is also the matter of money: NASA has no funding for a Europa lander, although several members of Congress support the concept.

The great fear of the Europa believers is not that the challenges of visiting this ice moon are too daunting, but that the process of rising to them will simply be too costly. Mars is closer, more accessible, and more familiar; if you just crunch the budget numbers, that's the place to go. But Europa is the world with the winning scientific numbers. If we invest the time and money, a mission to Jupiter's ocean moon could yield the most exciting figure of all: 2, the number of places in the universe where we know that life exists. 🚀

GO

HACK

YOURSELF*

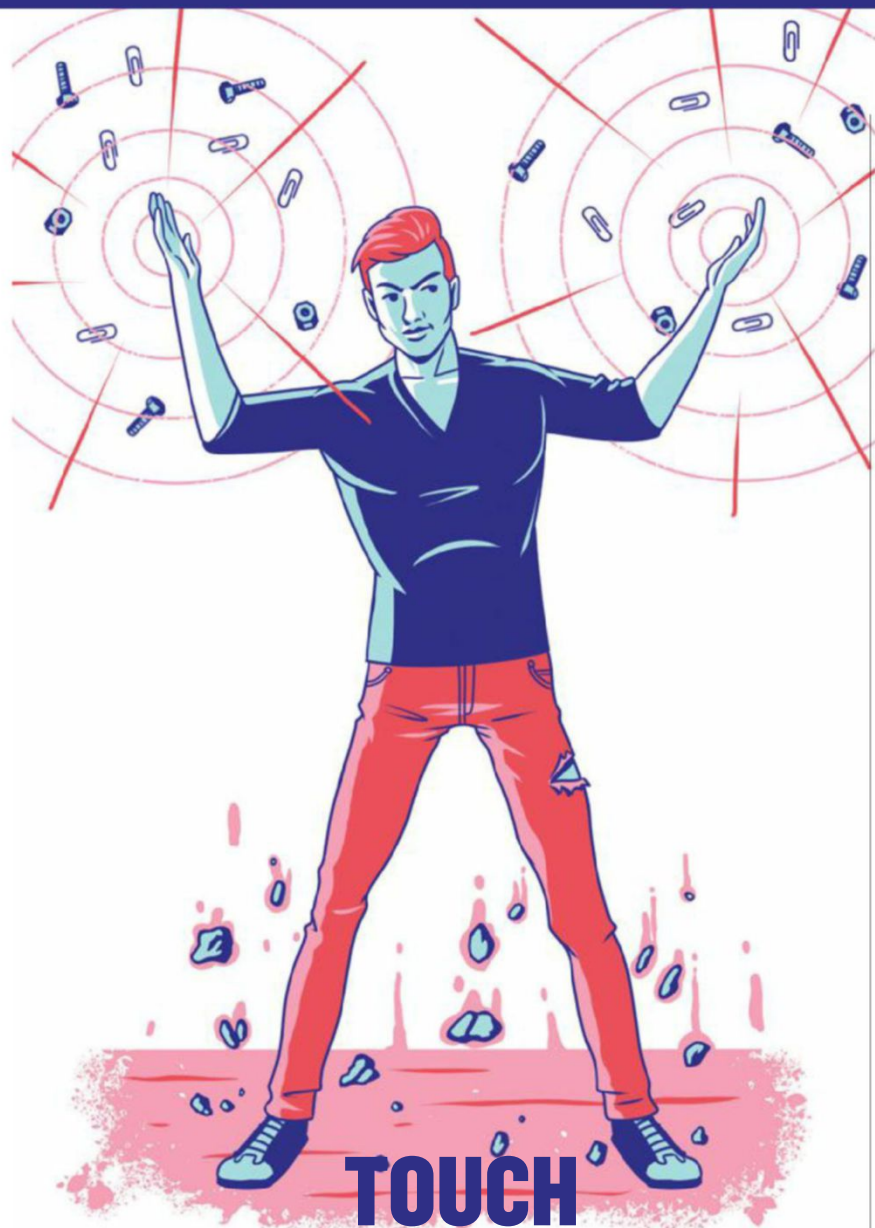
*NOT REALLY

**TIRED OF THE
BODY YOU HAVE?
CONSIDER A FEW
AFTERMARKET
OPTIONS.**

Gamers often perform repetitive tasks to improve their character's skill set, gain rewards, and advance to new levels. The process is known as grinding: Now, an underground movement has taken up that expression, calling themselves grinders, and they're trying to gain some of those same superskills—only in real life by hacking their bodies.

To cynics, the upgraded-self movement—aka body hacking—can seem a reckless and narcissistic pursuit. After all, treating your body like a home science kit can have serious consequences (scarring, bleeding, pain on the scale of passing out). Yet tinkering with human hardware is a centuries-old pursuit. Bolting titanium plates onto problem spines has become downright common. Today's transhumanists take it further. They seek to extend the senses and co-mingle them, allowing themselves to do things like detect Wi-Fi, hear colors, sense magnetic north, and see in the dark. Technology is driving the trend. But so are a few renegade surgeons—operating in an ethical gray area—and a growing number of innovative grinders, all of them hoping to one day push the cyborg off the Comic-Con floor and out onto the streets.

BY BOB PARKS | ILLUSTRATIONS BY MUTI



TOUCH ELECTROMAGNETIC FIELDS

Magnets are easy to install and among the first hacks grinders try. Piercing-shop staffers typically embed a barrel-shaped neodymium variety, the size of a grain of rice, beneath the skin of a finger. The magnets are coated in bio-proof materials such as titanium nitride (used to coat replacement hips), silicone, and Teflon. When one encounters an electromagnetic field, it vibrates against the nerves, enabling the user to feel things, like power transformers and microwave ovens. They're also good bar tricks: Dangle paper clips from your finger! But use with caution. One grinder injured the tissue near his implant—by opening a pickle jar.



Install Sonar

Want to sense distance like a dolphin? Bottlenose—from the hacker collective Grindhouse Wetware—creates sonar perception in an off-the-shelf kit (\$60). Its dolphinlike range finder locates an object in a dark room using an ultrasonic distance sensor. It then sends electromagnetic pulses to a magnet in the user's finger, providing a sense of things like an object's size and distance. As a user moves closer to the object, the sensations grow stronger. Bottlenose can also detect radiation or the presence of ethanol, and it can pick up Bluetooth signals. A thermal infrared sensor spots warm objects—such as a stove or a clothes dryer—from up to several feet away. There are also add-on sensors for detecting things like ultraviolet light and for sensing compass headings. For people without magnet implants, a wearable magnet works just as well, delivering the same sensory vibrations outside the skin, as long as the magnet is worn within the range of the Bottlenose device.



Become a Compass

We humans get lost, and finding our way usually means asking directions. For a 2014 report in the journal *Consciousness and Cognition*, researchers at the University of Osnabrück in Germany wanted to know if they could instead create a learned sense of direction. For seven weeks, nine male and four female subjects wore belts with 30 vibrating motors stitched onto an elastic fabric that indicated when they were facing magnetic north. The subjects biked and walked regularly. Over time, they improved their overall orientation abilities on a subcognitive level. "Today I stepped out of the train, and I immediately knew where I [had] to go," subject BWP9 said. "With the belt, one does not have to always care so much whether there is a turn ... one simply feels it!" Once the belts were removed, however, some users felt disoriented and insecure. Similar devices are available as kits, such as the North Paw from sensebridge.com (\$149) or as free plans on instructables.com.



GET SUPERHUMAN NIGHT VISION

The deepsea dragonfish, found in oceans of the Southern Hemisphere, swims 1.6 km below the water's surface. A chlorophyll derivative in its eyes helps it see in the dark—or rather in a red light cast by a bioluminescent organ. In March 2015, California biohackers Gabriel Licina and Jeffrey Tibbetts wanted to try a similar derivative, Chlorin e6. They bought 100 milligrams from a medical supplier for \$39. A heavy dose would have burned the eyes, so they diluted half in insulin and saline, adding the organic solvent dimethyl sulfoxide. Tibbetts pinned Licina's eyelids with specula and dosed the eyes. After two hours, Licina was able to identify people 50 feet away in a darkened area 100 percent of the time, while four control subjects had a 33 percent success rate. So far, there have been no bad side effects.

Meet the Borgs

In 1998, U.K. professor Kevin Warwick became the first person to have a transponder chip implanted under his skin, but only after receiving ethical approval to experiment on himself and enlisting a doctor to assist him. It wasn't until Seattle-based IT consultant Amal Graafstra had a chip implanted in each hand, in 2005, without seeking approval, that the grinder world found a spark. Graafstra uses the chips to open his home and car doors and to log on to his computer. He also sells them to grinders on his website *Dangerous Things*. Last year, Graafstra became the first to implant a tiny photovoltaic panel in his forearm to learn how much light traveled through the skin and whether it could power internal sensors such as a heart monitor. Though it generated a mere 50 microamps at 3 volts—about a 400th of the current needed to run an LED—he felt elated, saying, “it proves the value of citizen science.”



Hear Wi-Fi

Imagine walking down the street, and instead of looking for that little Wi-Fi sticker on the doors of coffee shops, you could hear a hotspot's presence. London journalist Frank Swain is partially deaf. He wears Starkey Halo hearing aids that link via Bluetooth to his smartphone. Last year, a sound-engineer friend hacked his phone's software, so now it sends melodies and Geiger-counter-like clicks to his hearing aids when it detects Wi-Fi zones. “I pick up a lot more data than you might think,” Swain says. “Routers give away a lot through the pitch of their digital signals, including the brand, the type of router, the Internet Service Provider, whether high security or low security. I can even home in on their location using stereo.”



Turn Fingers into Flash Drives

Computer-readable ID chips are now so small—a mere 3 mm to 6 mm long—that they can be inserted beneath the skin with the aid of a large needle. This is another simple gateway hack for grinders. Like magnets, the chips are typically implanted at piercing shops, without anesthesia, which generally requires a permit to administer. Using Radio Frequency Identification (RFID) and Near Field Communication (NFC), you can make chips operate dozens of consumer devices, such as RFID door locks. You can store data on them and transfer things like video-access codes to a friend's NFC-enabled Android smartphone—all with the simple wave of your hand.



Hear Colors

Colorblind artist and musician Neil Harbisson saw the world in gray-scale for the first 21 years of his life. Then, on December 2, 2013, in a Barcelona clinic, a surgeon (operating without ethical approval) drilled four holes into the occipital bone at the base of his skull and anchored a camera. Its flexible lens arcs over Harbisson's head to just above his brow, where it captures the color of any object Harbisson is looking at; a chip inside his skull transposes the color into a frequency (red becomes the musical note F; rose becomes E); and then turns each frequency into a vibration picked up by Harbisson's inner ear. A yellow sock sounds like the G note above middle C; the blue eyes of Nicole Kidman (who he once met) sound like B. Volume relies on color saturation. Fused to his body, the camera stalk feels like a long tooth, Harbisson says. Every few months, he has to charge a small battery to power the processor, camera, actuator, and wireless systems. There is no on/off button.



Shock Your Brain into Working Better

Electricity shot into the brain temporarily boosts intelligence, according to academic studies and, less convincingly, to adventurous amateurs. A 2015 analysis in *Restorative Neurology and Neuroscience* surveyed 13 studies that showed improved brain performance through transcranial direct current stimulation (tDCS) and random noise stimulation. The experiments used a very low current of up to 2.5 milliamps (usually corresponding to a maximum 18.5 volts) for no more than 20 minutes. Subjects then completed tasks in which they showed better memory, cognitive control, and math skills. Such experiments are typically done with research-grade equipment in a lab, not performed by amateurs. But with a great deal of risk, grinders have made their own tDCS devices. Some buy them ready-made online for as little as \$150. Either way, of all the questionable biohacks, definitely do not try this one at home.



IMPLANT HEADPHONES

Rich Lee, a salesman and grinder from St. George, Utah, wanted true wireless headphones. So he implanted a magnet in the small prominence (known as the tragus) in front of each ear. He then hacked his smartphone to send audio into a signal amplifier that relays it to a wired "antenna" necklace around his neck. The necklace creates an electromagnetic field around Lee's head. And the field induces vibrations in the ear magnets that Lee hears as music. "The sound quality is decent, maybe comparable to a cheap set of ear buds," Lee says. In one experiment, he connected the necklace to a small microphone attached to his heel, which senses subtle tremors in the ground. "I could detect a jogger coming up behind me on a paved road long before I could even see him," he says.

Manual

EDITED BY *Sophie Bushwick*

STATS

Time 2 hours

Cost \$26

Difficulty



Build Your Own Cotton-Candy Machine

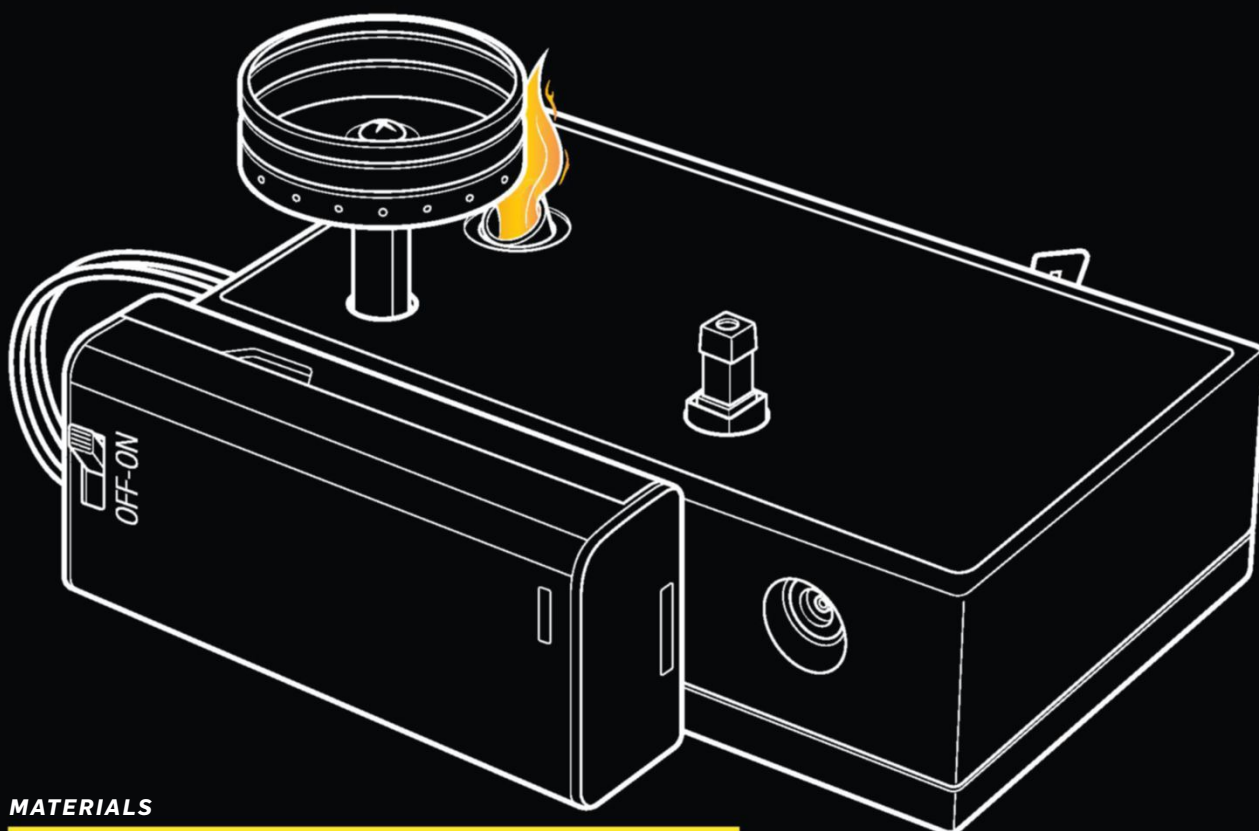


You don't need to wait for a carnival to satisfy your craving for cotton candy. Instead, build this portable, pocket-size machine to turn granulated sugar into an airy treat.

A DIY cotton-candy machine consists of a small metal container, repurposed lighter parts to provide heat, and a switch-controlled motor to set everything spinning. Slowly pour granulated sugar into the container, and flames from the lighters will melt it. As the motor spins, the liquid sugar will fly out through little holes in the container's sides, forming thin strands. A paper cylinder placed around the machine will capture them. Once they've built up, simply swirl a chopstick around the perimeter to gather the candy and taste your sweet success. **POCHOLO MANALAC**

continued on the next page

WARNING: Take care handling lighters and fuel, and keep hands and paper clear of the open flame.



MATERIALS

- Long-nosed lighter
- Torch lighter
- Wire
- Two-part epoxy
- Superglue
- Metal stand-off with a screw, washer, and nuts
- A small cosmetic aluminium container (found in drugstores) or a metal drink cap
- Small project box
- DC motor
- AA-battery holder
- Clay epoxy
- Paper, tape, rubber band, and chopstick

TOOLS



Push pin



Power drill



Soldering iron

INSTRUCTIONS

- To build a system for heating the sugar, first open both lighters. Harvest the large fuel tank, igniter, and hose from the long-nosed lighter and the torch head from the torch lighter.
- Use the long fuel hose to connect the fuel tank to the torch head.
- For an ignition line, wrap a short length of wire around the metal base of the long-nosed lighter's igniter and seal it with epoxy.
- Push the igniter's new wire through the torch head—where the torch lighter's wire previously was. This is the main ignition line.
- Connect the main ignition line to the brass part of the torch head. Seal with superglue.
- Next, set up the spinning chamber. Epoxy the metal stand-off to the shaft of the motor. (When joining two parts together with epoxy, sanding both sides will yield a stronger bond.)
- With the push pin, punch holes all the way around the sides of the aluminum container, or drill tiny holes in the metal drink cap. Find the center of the container and drill through it. Add the screws, washers, and bolts to it, and screw it in place on the motor's stand-off.
- Solder the battery pack's terminals to the motor. Since the screw tightens clockwise, make the motor spin counterclockwise to prevent it from unscrewing.
- To prepare the project box, plan where you will be placing the fuel valve, igniter, torch head, and spinning chamber. Mark each spot with a marker, and then drill the holes. You may use the pictures as a guide.
- Epoxy the motor in place in the box. Glue the battery pack to the outer side of the box. Seal the igniter in place—the end should stick out of the box—with clay epoxy.
- Before sealing the torch system in place with the clay epoxy, measure the torch head and aim it at an angle so the flame will touch the near edge of the metal container.
- To operate the cotton-candy machine, tape paper into a cylinder that fits around it. Then switch on the motor, squeeze the fuel valve (and hold it in position with a rubber band), and spark the igniter. Let the machine heat for 10 seconds, then place the paper cylinder around it and slowly add the sugar. Collect the candy with a chopstick.

EPIC HOLLYWOOD PROPS, REMIXED



When a new movie hits theaters, most people grab popcorn. Instead, these DIYers grabbed their toolboxes. Inspired by this year's biggest action films, they built real-life versions of three outrageous props.

LEVI SHARPE



FLAMING UKULELE

In *Mad Max: Fury Road*, the Doof Warrior plays heavy metal on a flamethrowing double-neck

guitar. After watching the movie, Caleb Kraft decided to build his own "adorably dangerous" version of the instrument:

a flamethrowing ukulele. Kraft used a modified caulking gun to squeeze butane into a hose and added an igniter switch. With zip

ties, he attached the whole apparatus to the back of a ukulele, creating a cute, strummable instrument of destruction. "Movies and

videogames are such easy inspiration," Kraft says. "They are the manifestations of what we think would be awesome to exist."

191,271,109

Domestic box-office dollars earned by *Avengers: Age of Ultron* over its opening weekend, the third-highest opening weekend ever

HULKBUSTER SUIT

In 2014, toy designer James Bruton created a replica Iron Man suit that garnered millions of YouTube views. "I thought that if I ever went to a convention, I should have something super-cool to wear," Bruton says. "So I built something that I wanted to own." Now, he's using his YouTube channel to document his work on the superhero's bulkier "Hulkbuster" suit, which appears in *Avengers: Age of Ultron*. Bruton's suit has a plywood frame covered with red foam plates. Bungee cords, snowboard bindings, and 3-D-printed parts serve as movable joints. Bruton also outfitted the suit with pop-up shoulder cannons and a glowing chest plate.

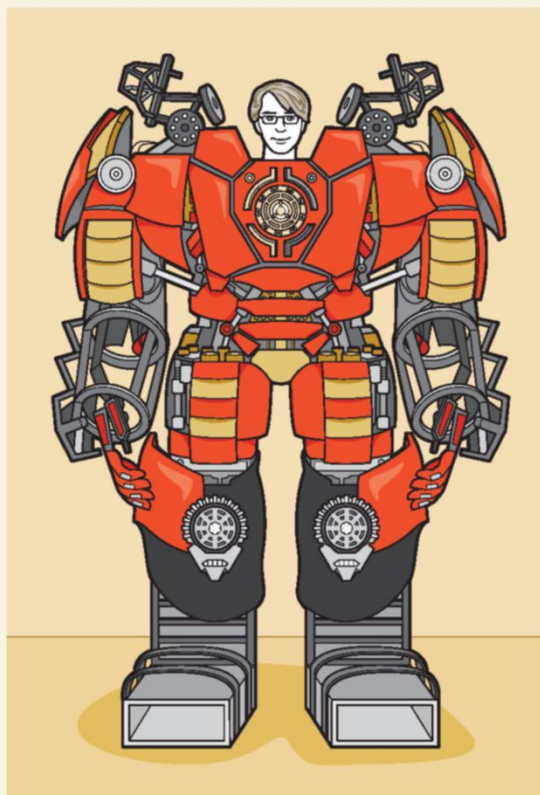


BB-8 DROID

When industrial designer Christian Poulsen saw a BB-8 droid roll onto the stage at an event for *Star Wars: The Force Awakens*, he was struck by the simplicity of the design: a

large sphere with a dome on top. "When I saw that," Poulsen says, "I thought, 'How hard could it be to make my own?'" An app-controlled toy ball called Sphero would make the perfect base, he realized.

First he sawed it open to insert a magnet. Then he carved a head out of foam and embedded a magnet in that too. The magnets hold the head to the body as the toy rolls around, leaning slightly off-kilter.



This Ballistics Box Measures Fastballs

DIY-history columnist **William Gurstelle** gives ancient warfare a modern spin.



About 300 years ago, English scientist Benjamin Robins decided to measure the speed of a bullet, a task that led him to invent the ballistic pendulum. This device tracks the momentum of a projectile, allowing users to calculate the speed and energy as well. Although the chronograph later replaced that method, the ballistic pendulum has a great advantage: It relies on very simple mathematics.

Basically, the user fires a projectile—in Robins' day, a cannonball or musket shot—at the pendulum. The faster it's moving, the farther the pendulum will swing, pulling measuring tape along behind it. Robins determined that the distance the pendulum swings, along with its weight and that of the projectile, can be used to figure out the projectile's velocity. Bullet speed doesn't interest me, but a ballistic pendulum can measure the speed of any object—including a baseball. With baseball season in full swing, I set out to build one.

To construct the frame, I used dimensional lumber stiffened with plywood gusset plates. A plastic milk crate lined with crumpled newspaper served as the base of the pendulum. I attached the top of the crate to an aluminum bar, which I then connected to a wooden dowel. The dowel fit through holes at the top of the frame so it could swivel freely like a spit. Finally, I attached measuring tape to the bottom of the crate and ran it through a slot in the middle of the frame. The slot provided just enough friction to keep the tape from sliding



back after the pendulum hit peak swing, thus recording the measurement. The project took me about half a day and cost less than \$50.

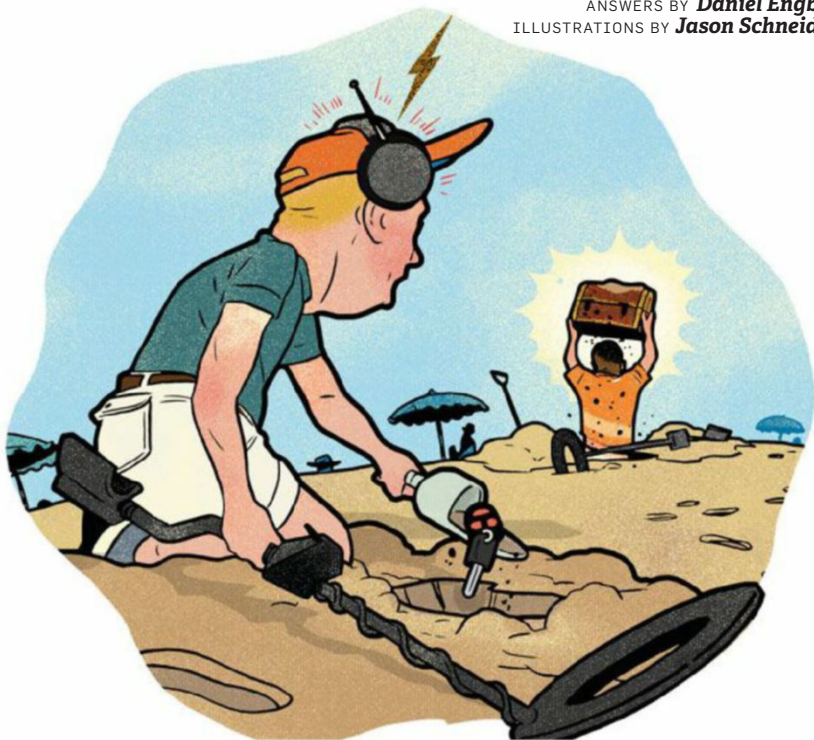
To gauge my fastball, I just pitch the ball into the milk crate. The crate

swings up, and the tape registers the distance of the pendulum's arc. Using Robins' original equations, I can calculate my pitch speed. It's tougher than using a chronograph or a radar gun—and way more satisfying.

Go Ahead...

Ask Us Anything

ANSWERS BY **Daniel Engber**
ILLUSTRATIONS BY **Jason Schneider**



Q: DO THOSE GUYS WITH METAL DETECTORS EVER FIND TREASURE?

Short answer Every once in a (very long) while.

A:

In 1975, a metal-detector hobbyist named Morton Leventhal made the front page of *The New York Times* when he stumbled on a piece of Roman antiquity. The Wall Street stockbroker was scouring a field overlooking the Jordan River in Israel when his Metrotech device started bleeping. He pulled out his knife and scraped away the dirt to reveal a life-size bronze statue of the Roman Emperor Hadrian, from the second century—a piece so rare it's now in the Israel Museum in Jerusalem.

Finds like that fueled the metal-detecting craze of the late-1970s and 1980s. "Detectorists" of that era benefited

from a major technology upgrade: the Very Low Frequency detector, which offered better ground-penetration than earlier models. In fact, hobbyists became so adept at finding buried treasures that professional archaeologists recruited them to scour Civil War battlefields and other historic sites, which they still do today.

But their prowess might be a bit overblown. Amateurs do, on rare occasions, turn up valuables: an Iron Age cache of Celtic coins in June 2012, another collection of Roman coins a few months later. But that doesn't mean it's a good way to prepare for retirement. A 1990s British survey of the hobbyists found that hardcore detectorists reported a median 13 finds per year.

"It's incredibly unlikely to find an item that is worth millions of dollars," says Suzie Thomas, a museologist at the University of Helsinki in Finland. She adds that most detectorists are simply in it for the hunt. "If you're in it to get rich, you'll probably give up after a few months."



Q: Can hypnosis kill you?

Short answer No, but you're getting veeeeeeery sleepy.

A:

The first account linking hypnosis and death in the medical literature was in 1894. Ella Salamon, niece of a Hungarian count, was put into a trance and then "fell from her chair with a hoarse cry," according to an attending doctor. "There is no doubt that she died in hypnosis," said Richard von Krafft-Ebing, a noted psychiatrist of the time, "but that she died by hypnosis is questionable."

Accounts of such fatalities or psychiatric harm from hypnosis have appeared sporadically ever since. In 1979, a stage hypnotist asked a young Israeli mother to regress to childhood—a time when she'd been hiding from the Nazis. She later reported that the newly uncovered memories put her in a state of distress for years. Other reports tell of trance subjects left stuporous and suicidal.

But these cases are anecdotal. Studies suggest that the negative side effects are generally mild at worst. In the 1970s, researchers from California State University in Fresno looked into the risks by hypnotizing 209 undergraduates. A few suffered headaches or nausea; 25 reported feeling light-headed or drowsy—hardly worse than what the students experienced taking an exam or sitting through a lecture.

"Hypnosis, in and of itself, isn't dangerous," says psychologist Bruce N. Eimer. It can be a therapeutic tool; but like all tools, he says, in the hands of someone incompetent or who uses it inappropriately, it can cause harm. "Would a massage therapist perform acupressure on an 84-year-old with osteoporosis?" Eimer asks. Probably not. Similarly, it would be unwise for a clinician to use hypnosis without first assessing if a patient is too psychologically fragile.



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